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HAZARDOUS CHEMICAL VAPOR REDUCTION DEVICE DEVELOPMENT.(U)

OCT 79 D MOTHERWAY, R HAMEL, F COONEY

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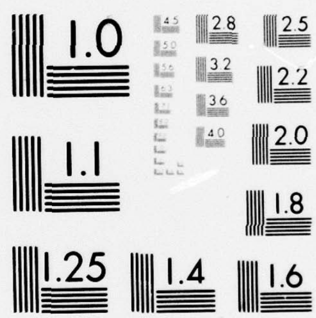

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16. Abstract

The Vapor Reduction Device (VRD) was developed for use by Coast Guard Strike Teams during emergency transfer of liquid hazardous chemicals and petroleum products. The device is intended to be placed around and over deck openings which are being used for cargo offloading in order to reduce vapors which might degrade protective clothing or other equipment used on deck by Coast Guard Strike Team personnel.

Various design concepts were evaluated prior to the prototype selection. Materials used in the design are compatible with lists of chemicals which adequately represent those in the Chemical Hazards Response Information System (CHRIS) manual.

The device can be used over a variety of deck openings from 12-1/2 inch diameter flush deck Butterworth openings to raised cargo hatches with coamings 30 inches in diameter and 48 inches in height. The top section is designed to provide a seal around Air Deliverable Anti-Pollution Transfer System (ADAPTS) hoses and allows the pump system to be inserted or withdrawn without removing the VRD.

Preliminary tests to measure the effectiveness of the VRD conducted at CGR&DC showed that the device has the capability of limiting the vapor concentration level around a tank opening to one (1) ppm when tested under the simulated conditions described in this report.

17. Key Words Vapor Reduction Device (VRD) Air Deliverable Anti-Pollution Transfer System (ADAPTS) Hazardous Chemical Offloading Vapor Reduction Personnel Protection	18. Distribution Statement Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

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METRIC CONVERSION FACTORS

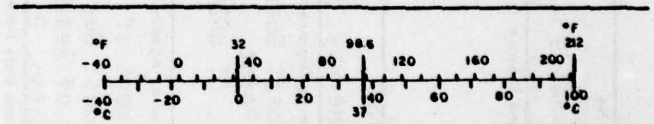
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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TERMS AND DEFINITIONS

VRD	Vapor Reduction Device under development at R&DC.
ADAPTS	Air-Deliverable Anti-Pollution Transfer System used by Coast Guard personnel for emergency offloading of stricken vessels.
Tank Openings	The various access openings through which emergency pumps can be inserted into a cargo tank.
Butterworth Opening	A particular type of tank opening designed for the Butterworth tank-cleaning system.
Ullage	The general term used to describe the free space above the liquid level in a cargo tank. Deck openings sometimes referred to as ullage openings.
Tripod	An adjustable steel tripod used to lift emergency pumps on board as well as lower and support the submersible pump. It will also support the pump hoses and VRD.
Lightering	The process of pumping out (offloading) tankers at sea.
Strike Teams	U.S. Coast Guard specialized groups trained and ready to respond to incidents involving petroleum or hazardous chemical spills.
CHRIS List	Chemical Hazards Response Information System (CG-446).
Velcro	A fastener consisting of two mating tapes. One tape has small hooks which mate to the other tape that is covered with small loops. When pressed together, they form a secure closure.
TK4 Pump	A liquid chemical pump manufactured by Framo and being evaluation tested by the U.S. Coast Guard.
OVA	Organic vapor analyzer used for qualitative and quantitative analysis of chemical vapors.
G-EOE	Ocean Engineering Division, Office of Engineering, Coast Guard Headquarters.
G-WEP	Marine Environmental Protection Division, Office of Engineering, Coast Guard Headquarters.
G-DMT	Operations and Environmental Technology Division, Office of Research and Development, Coast Guard Headquarters.

CG R&DC	Coast Guard Research and Development Center.
PTA	Proposed Technical Approach: A program document which provides technical analyses of proposed development, assessing the technical risks as well as the costs involved, recommending methods for accomplishing an objective.

LIST OF CONTACTS

USCG Atlantic Strike Team, Elizabeth City, NC
USCG Gulf Strike Team, Bay St. Louis, MS
USCG COTP New York, NY
Stolt Nielsen Tanker Division, Greenwich, CT
James River Reserve Fleet, VA
Butterworth Systems, Florham Park, NJ
The International Chamber of Shipping, London, England
Adams Magnetic Products, Chicago, IL
Fed-Flex Hose Company, Painesville, OH
McMaster-Carr Supply, Chicago, IL
Carlisle Tire and Rubber Company, Philadelphia, PA
Gulf Seal Corporation, Houston, TX
B.F. Goodrich, Armonk, NY; Akron, OH; Bethesda, MD
DuPont Company, Fairfield, CT; Newark, NJ
Eastwind Industries, Dover, DE
Globe Linings, Incorporated, Long Beach, CA
Washington Aluminum Company, Incorporated, Baltimore, MD
Haywood Manufacturing Company, Incorporated, Elizabeth, NJ
Scotchmate 3M, Minneapolis, MN
Velcro Corporation, Manchester, NH
3M Company, Freehold, NJ; Boston, MA
Drum Parts Midwest, Thornton, IL
Plymouth Rubber Company, Canton, MA
Overbeke-Kain Marine Company, Cleveland, OH
Marine Moisture Control, Inwood, NY
Camlock Flange Sales Corporation, Inwood, NY
Dover Marine Supply, Woodside, NY
Ace Gasket Company, Mt. Vernon, NY
Chicago Gasket Company, Chicago, IL
A.W. Chesterton Company, Stoneham, MA
Transworld Adhesives, Boston, MA
TFE Company, Warwick, RI
Union Carbide Help Seminar, Brownsville, TX
Carlton Precision Machine, Norwich, CT
O'Connor & Milgram Sailmalers, Marblehead, MA
Offshore Devices, Peabody, MA

1.0 PURPOSE

To develop an effective Vapor Reduction Device for use during emergency transfer operations of liquid hazardous chemical cargoes. The device is intended to be placed around and over deck openings which are being used for cargo offloading in order to reduce vapors which might degrade protective clothing or other equipment used on deck by Coast Guard Strike Team personnel.

2.0 BACKGROUND

During normal offloading or lightering operations aboard tankers and barges carrying liquid chemical or petroleum products, the problem of hazardous vapor is minimized through required design features and utilization of procedural controls. However, under abnormal situations such as the grounding of a tanker or barge, these design features and procedures are often inoperative or ineffective.

The problem of petroleum vapor hazards resulting from distressed vessels and a discussion of the capability and risk associated with producing hardware to eliminate these vapors to the extent that explosions and fires could not occur is documented in some detail in reference (1).

In general, the conclusion is drawn that, although effective flash screens and vapor seals could be developed for use around the stricken vessels' offloading hatches or on the receiving hatches on lightering vessels, progressive hull damage often occurs forming uncontrollable sources of vapors. Additionally, it is implied in reference (1) that vapor control devices could be elaborate and the time spent rigging them might better be spent in stemming further damage to the vessel or reducing the degree or threat of pollution. It is further concluded that the best way to eliminate the fire and explosion problem is through employment of proper operational procedures and the elimination of ignition sources.

The related problem of chemical vapors is also discussed briefly in reference (1). The same philosophy with regard to vapor reduction to eliminate fire or explosion hazards is evident here as in the case of petroleum cargoes. The primary concern with chemical vapors is, however, the potential for vapor degradation of protective clothing or other equipment used in lightering or offloading operations. This specific concern provides the impetus for the effort to develop a vapor reduction seal for use during emergency transfer operations of liquid hazardous chemicals.

The conclusions drawn in reference (1) with regard to the impracticability and risk associated with producing a sealing device which could "eliminate" vapors were adopted for the purposes of this development effort. With this in mind the specific hardware developed was termed <u>Vapor</u> <u>Reduction</u> <u>Device</u> (VRD). Emphasis was placed on providing a device which will reduce as much vapor as possible consistent with established operational and design requirements.

3.0 APPROACH

The approach in this effort to develop a Vapor Reduction Device (VRD) closely follows the approach to other Hazardous Chemical Discharge Prevention and Reduction hardware-oriented tasks and proceeds with the following technical format.

In the problem definition of this task, a more detailed analysis of the particular problems involved with reduction of hazardous vapors, including deck opening configurations and discharge hose size, was conducted beyond that described by the Program Manager (G-WEP) and the Support Manager (G-DOE) in references (1), (2) and (3).

From this problem definition evolved the development of operational and design requirements as well as the design parameters and considerations needed to complete the requirements determination phase of this development task. The ensuing design concept definition produced competing concepts all meeting the determined requirements.

These competing concepts were evaluated and the selection was made of the most viable ones for further development into pre-prototype models. Engineering and field demonstrations of these pre-prototypes by CG Strike Teams and R&DC technical personnel resulted in design modifications that were incorporated into the prototype fabrication of the VRD.

Following the final hardware evaluation and vapor reduction tests, the concluding efforts in this task involved a design review and deliverables consisting of documentation of development work in the form of a final report, bill of materials, drawings, prototype hardware and operating instructions.

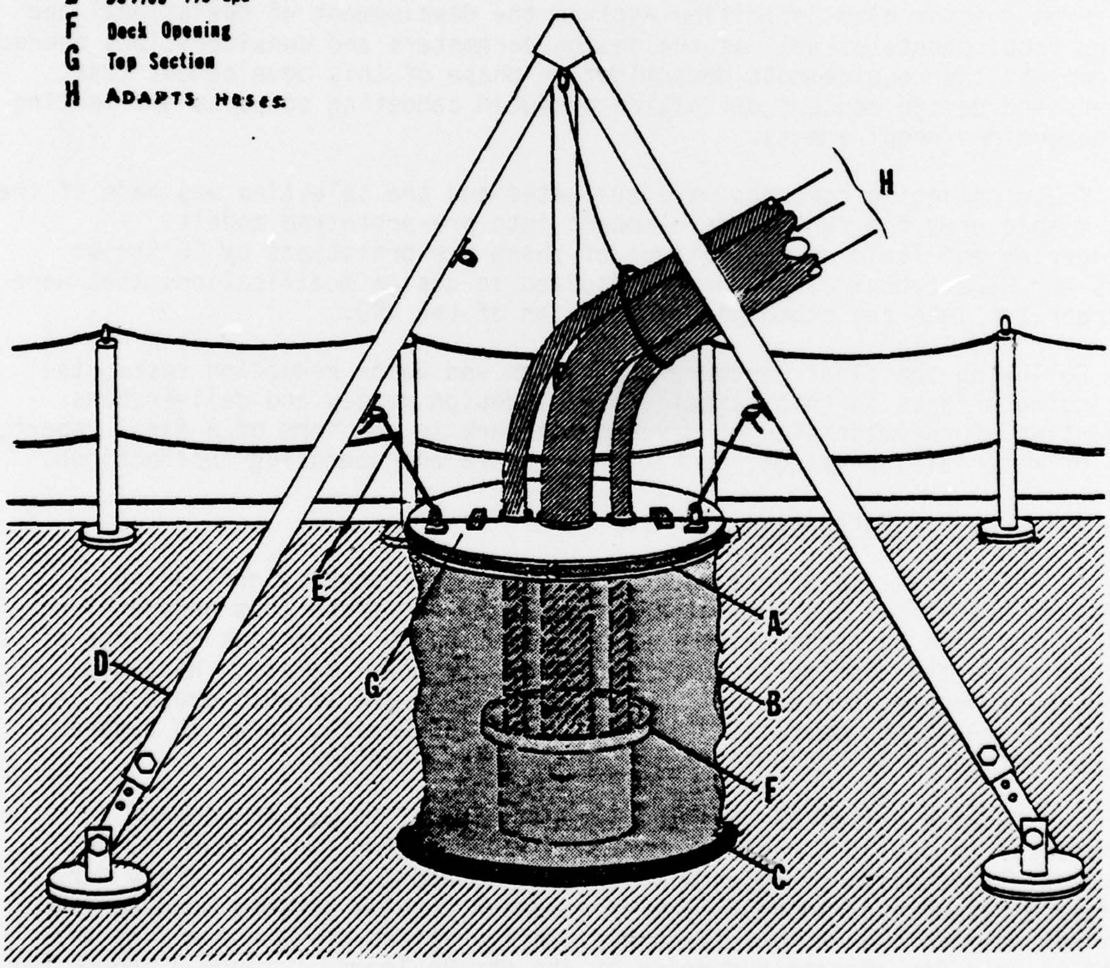
3.1 Problem Definition

The presence of hazardous vapors during emergency offloading (pumping) operations presents a definite hazard to Strike Team personnel on scene. The need has been determined for a device to cover tank openings of various sizes and configurations to increase personnel safety. Hazardous vapor could degrade protective clothing and reduce the effectiveness of self-contained breathing apparatus. A Vapor Reduction Device, shown as a general concept in Figure 1, could serve to reduce this potential.

At the outset of this development effort, it was considered impractical to design a device for total vapor elimination. However, any substantial reduction of vapor will provide an added margin of safety for emergency response personnel. The development problem becomes more defined when we consider the various types and configurations of tank openings that would be used for emergency pumping by the Strike Teams. Figure 2 shows four general types of tank openings to be concerned with when considering concepts for a device that could be used for most offloading cases.

COMPONENTS

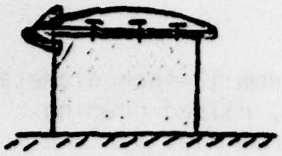
- **A** Skirt-To-Top Connector
- **B** Flexible Fabric Skirt
- **C** Skirt Bottom Deck Attachment
- **D** ADAPTS Tripod
- **E** Device Tie-ups
- **F** Deck Opening
- **G** Top Section
- **H** ADAPTS Hoses



VAPOR REDUCTION DEVICE

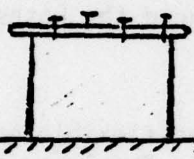
General Concept

Fig. 1

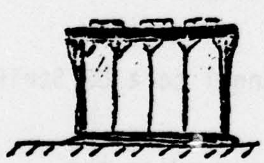


FOLDBACK CARGO HATCH COVERS CAN BE REMOVED TO ALLOW THE USE OF THE VRD. MOST ARE FITTED WITH PIN OR BOLT DETACHMENTS.

FLUSHDECK OPENINGS SUCH AS A BUTTERWORTH ARE WIDELY USED. VRD DIRECT COVER OR DECK ATTACHMENT CAN BE USED IN THIS CASE.



RAISED HATCH COAMINGS VARY IN LENGTHS UP TO 42 INCHES FROM THE DECK. BOTH DRAW-STRING SKIRT ATTACHMENT AND DECK ATTACHMENT METHODS ARE APPLICABLE.



RAISED HATCH WITH STRUTTED COAMING PREVENTS USE OF DRAW-STRING SKIRT OR BAG. DECK ATTACHMENT OF THE VRD APPLICABLE IN THIS CASE.

TANK OPENINGS VARY WIDELY IN CONFIGURATION, SHAPE, AND SIZE. GENERALLY THE OPENING DIAMETERS ARE FROM 12 INCHES TO 30 INCHES. THE MINIMUM DECK OPENING DIAMETER FOR ADAPTS USE IS 12 INCHES.

Deck Openings and Hatches

Fig. 2

The majority of deck hatches or ullages range from 12-inch diameter flush mounted deck openings to 30-inch wide, 36-inch high, raised coaming hatches. The top leading edges of these openings range from flat surface flanges to knife-edge rims. The shape of these openings can vary from circular to oval. When these variables are combined with factors such as rough deck surface or slickness due to a liquid film, it is easy to recognize that a device with wide application and flexibility is required to overcome these problems.

The VRD must be capable of use with both the Coast Guard ADAPTS pumping system and the Framo TK-4 hazardous chemical pump presently being evaluated for use by the Coast Guard. The main difference in these two systems that concern us in the development of a VRD is the fact that the ADAPTS discharge hose has a diameter of 6 inches while the TK-4 hazardous chemical pump has a 4-inch diameter discharge hose. Both systems have two similar 2-inch hydraulic hoses in addition to the main discharge hose.

The VRD must allow easy insertion and positioning of either pump and provide a significant reduction in vapor emanation from around the hoses during pumping operations.

The mid section (skirt) has to be large enough and flexible enough to cover the range of hatch configurations mentioned above. The lower skirt section, or bottom, must be capable of providing holding power to the deck regardless of deck movement, deck obstacles or deck surface conditions and must also provide a near perfect obstruction to the escaping vapors.

3.2 Requirements Definition

The operational and design requirements for development of a VRD were compiled from a number of sources including:

(1) A visit by Coast Guard R&D Center personnel to a CG Strike Team to obtain their input.

(2) Telephone contacts to commercial firms regarding the state-of-the art on emergency offloading techniques and hardware. (See List of Contacts).

(3) Section 4.0 of the Proposed Technical Approach (PTA) for project 4151, Hazardous Chemical Discharge Prevention and Reduction, which states specific goals to be met in the design of any concept, method, or device used in this effort.

(4) The requirements outlined in reference (1) regarding vapor hazards in ADAPTS pumping operations.

3.2.1 Operational Requirements

1. Versatility - The device should be designed to be used with as many configurations of tank openings as practicable as described in the problem definition.

2. Size and Weight - The device should be made to be carried on scene by one person and installed by no more than two persons.

3. Deliverability - The VRD components should be made compact and packaged for delivery by Coast Guard aircraft or vessel.

4. Durability - The device should withstand rough handling, exposure to the elements, and remain operable without deterioration during pumping operations.

5. Operability - The VRD should be relatively simple to set up and operate so that it does not deter from the other tasks involved in emergency offloading.

3.2.2 Design Requirements

1. Compatibility - The VRD is to be used with Strike Teams ADAPTS and TK-4 hazardous chemical pumping systems; therefore the materials used in the device should be compatible with as many liquid chemicals as feasible that are contained in the CHRIS manual.

2. Pump and Hose Considerations - The device must be designed to allow the pump's two hydraulic hoses, larger diameter discharge hose, and the pump lifting cable to be lowered and raised as required in a fast and simple manner. In addition, the device should be constructed to withstand a degree of pulsating motion and force at the points where hoses pass through the VRD. A gasket or similar elastic material would be required to compensate for this dynamic motion.

3. VRD Components - To satisfy its function, i.e., to reduce vapors, the device requires a top section to fit snugly around the hoses, a flexible skirt to cover various size hatches and deck openings, and a bottom section that would serve to hold the VRD secure to the deck. A consideration to design the top so that it could be placed directly on the tank opening, where applicable, would be explored. In addition, the method of securing the skirt by a draw-string concept as an alternate means must be included in the designs.

Generally, most VRD concepts evolved with the design of three basic sections; namely, the top, the skirt, and the bottom. More specifically, the requirements for the top included provision to insert either the ADAPTS or hazardous chemical pump and hoses and provide a vapor seal around the hoses during pumping operations. The top would also provide a means to suspend the VRD from the tripod (Figure 1). The circumference of the top section should be designed such that the skirt section could be attached. A flat underside for the top is a consideration to allow it to set unobstructed on a hatch opening should it be used as a direct cover. Although this may be feasible, it is not considered a prime requirement and is not considered to be the most effective method of VRD operation.

The skirt section must be designed and fabricated to cover a variety of hatches or openings. The flexibility in shape to adjust to hatch configurations and deck obstacles is a major requirement. The skirt vertical seam could be either bonded (non-open) or an open/close concept depending on the other VRD design concept components it would be used with. Considerations for material compatibility, methods of attachment to both the top section and bottom deck securing section are required in this skirt design effort.

The bottom section is designed to hold the skirt section securely to the deck and provide a vapor seal. This section is fitted and attached to the skirt section either as a permanent attachment or removable component. The skirt section has a draw string to provide an alternative means to secure the VRD to the coaming of a raised hatch, if feasible.

3.3 Concept Definition:

This section discusses and presents pictorially various concepts for the top, skirt and bottom sections of the VRD.

3.3.1 Top Section

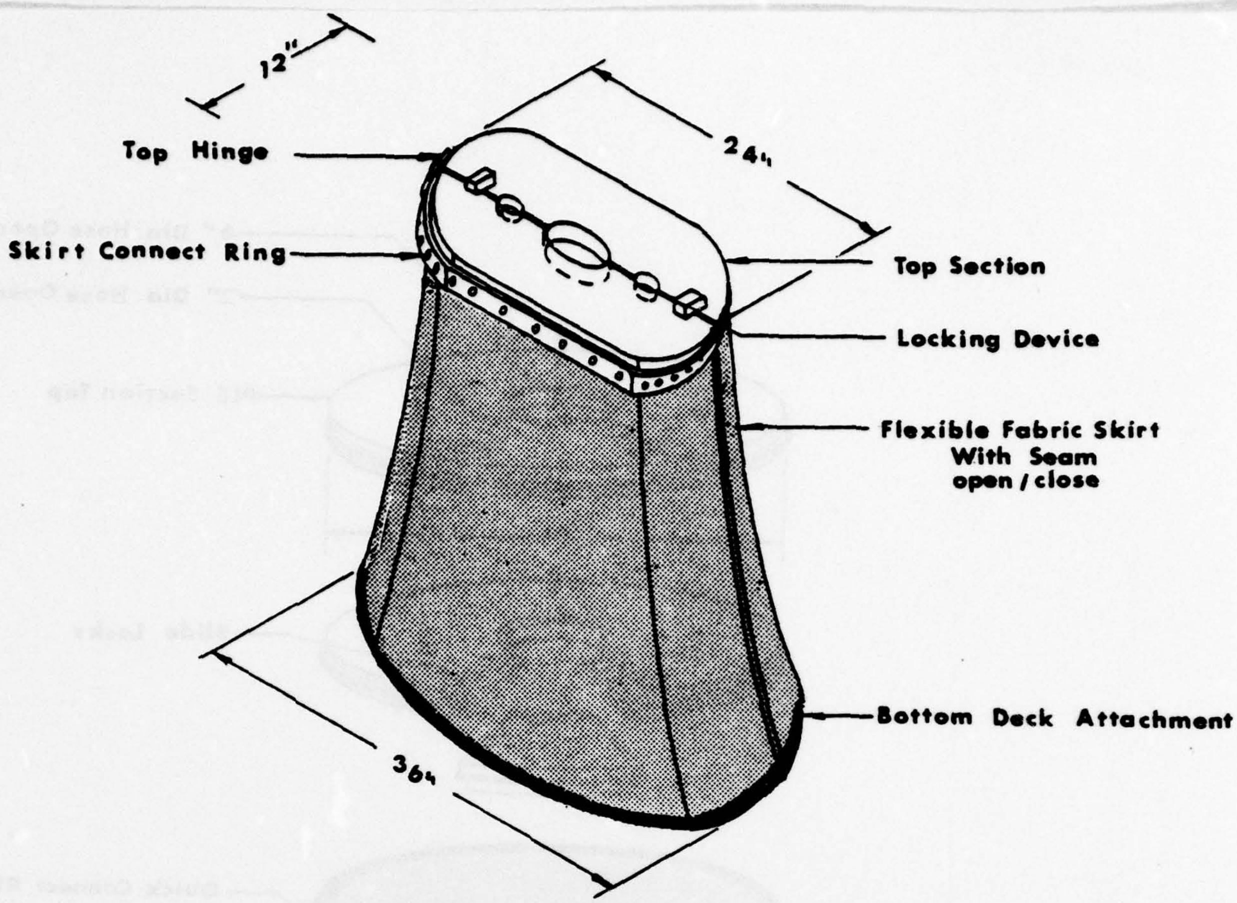
a. Hinged Top

This concept, illustrated in Figure 3, consists of two sections joined at one end by a hinge. Adjustable latches on the top are designed to hold both sections secure once the top has been closed around the ADAPTS hoses. Gaskets are fitted to the hose openings to provide a vapor seal around the hoses. Eyebolts attached to the top allow the VRD to be hung from the ADAPTS tripod. A hinged top concept used with an open/close skirt section is advantageous because the entire VRD can be set around the hoses or taken away without moving the inserted pump. The open/close skirt seam and the hinged top may not provide the level of vapor reduction found in other bonded seam concepts.

b. Pie Section Top

This concept, shown in Figure 4, consists of two distinct top pieces. The larger female section can be fitted around the hoses of the pump. With the hoses set in position in the female top section, the male section is replaced. A set of latches hold the two top pieces secure.

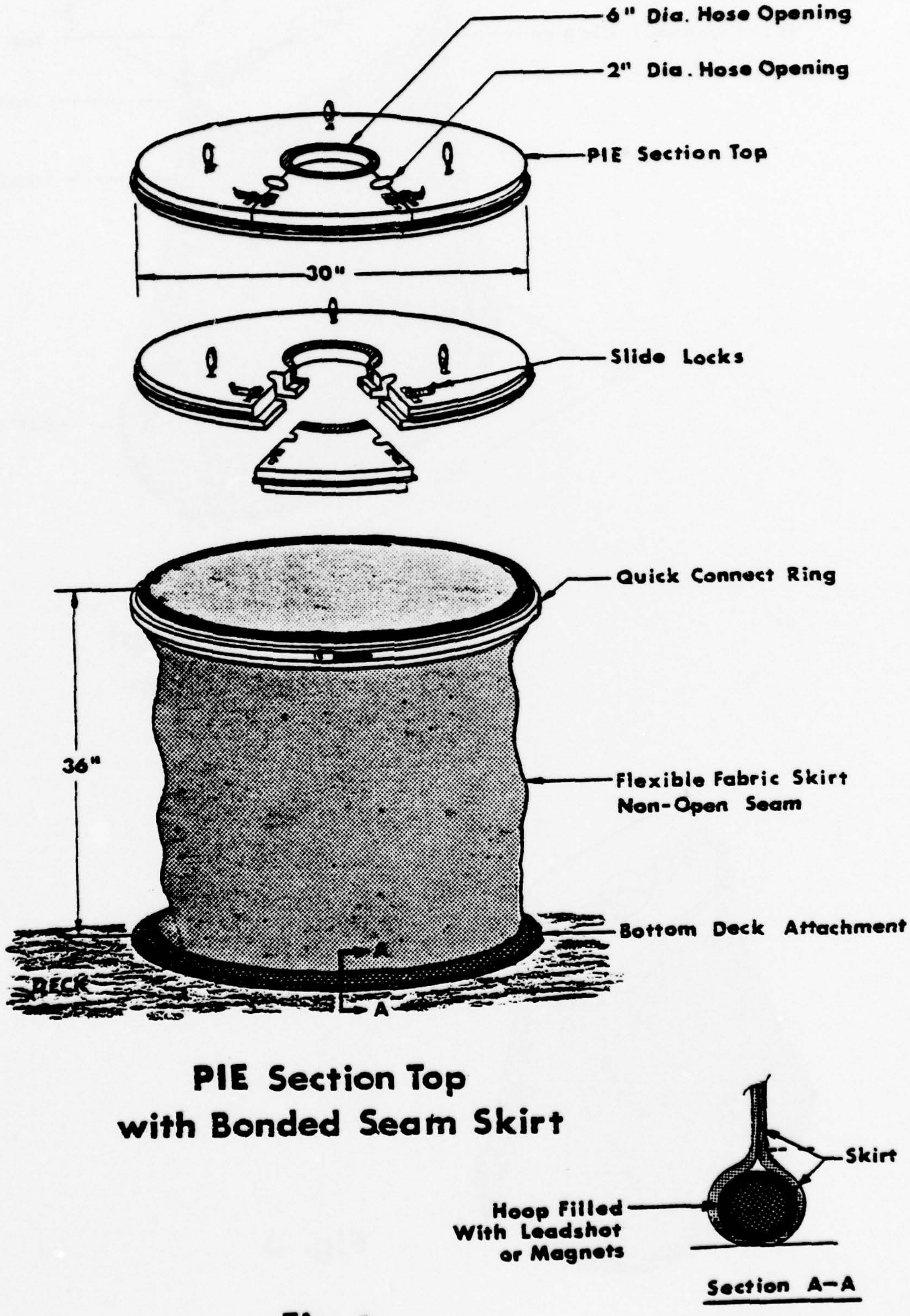
The outer rim of the circular top is designed so the skirt can be attached to the top section using a quick-connect metal ring. As in other top concepts the hose openings will be fitted with flexible rubber gasket material to reduce vapor leakage around the hoses. This design is for use with a bonded seam skirt. The skirt would be placed over the tank opening, the pump inserted through the top of the skirt section and the top pieces would be fitted together and connected to the skirt. This VRD operation requires more manipulation than other concepts and could prove to be a major disadvantage.



Hinged Top Concept
open/close seam

Open Position

Fig. 3



PIE Section Top
with Bonded Seam Skirt

Fig. 4

c. Slide Top

This concept, shown in Figure 5, has three basic sections: two top slide panels and a base ring. The slide panels, when open, allow enough space (approximately 12 inches) for the ADAPTS or TK-4 pump and hoses to pass down through the top ring into the tank opening.

The slide panels can be closed against the hoses and secured. This VRD concept can be placed over the tank opening as one unit and either the ADAPTS or TK-4 pump and hoses can be inserted or removed simply by sliding the panels open. This is a distinct advantage. Two sets of slide panels must be provided; one set with a 6-inch ADAPTS discharge hose opening, and one set with a 4-inch TK-4 discharge hose opening.

d. Two Piece Top

This concept is similar to the hinged top idea in that it consists of two identical top halves. The difference, however, is that this top is not hinged on one end, but separates completely. The halves fit snugly together with fitted dowel and hole connectors. A top latch holds both sides in place. A quick-connect skirt hoop will attach the top section and skirt together as well as provide additional holding support to the top halves as illustrated in Figure 6.

This top design might have a tendency for weakness in the center and not withstand the hose movements during normal operations or when the pump is lowered or raised.

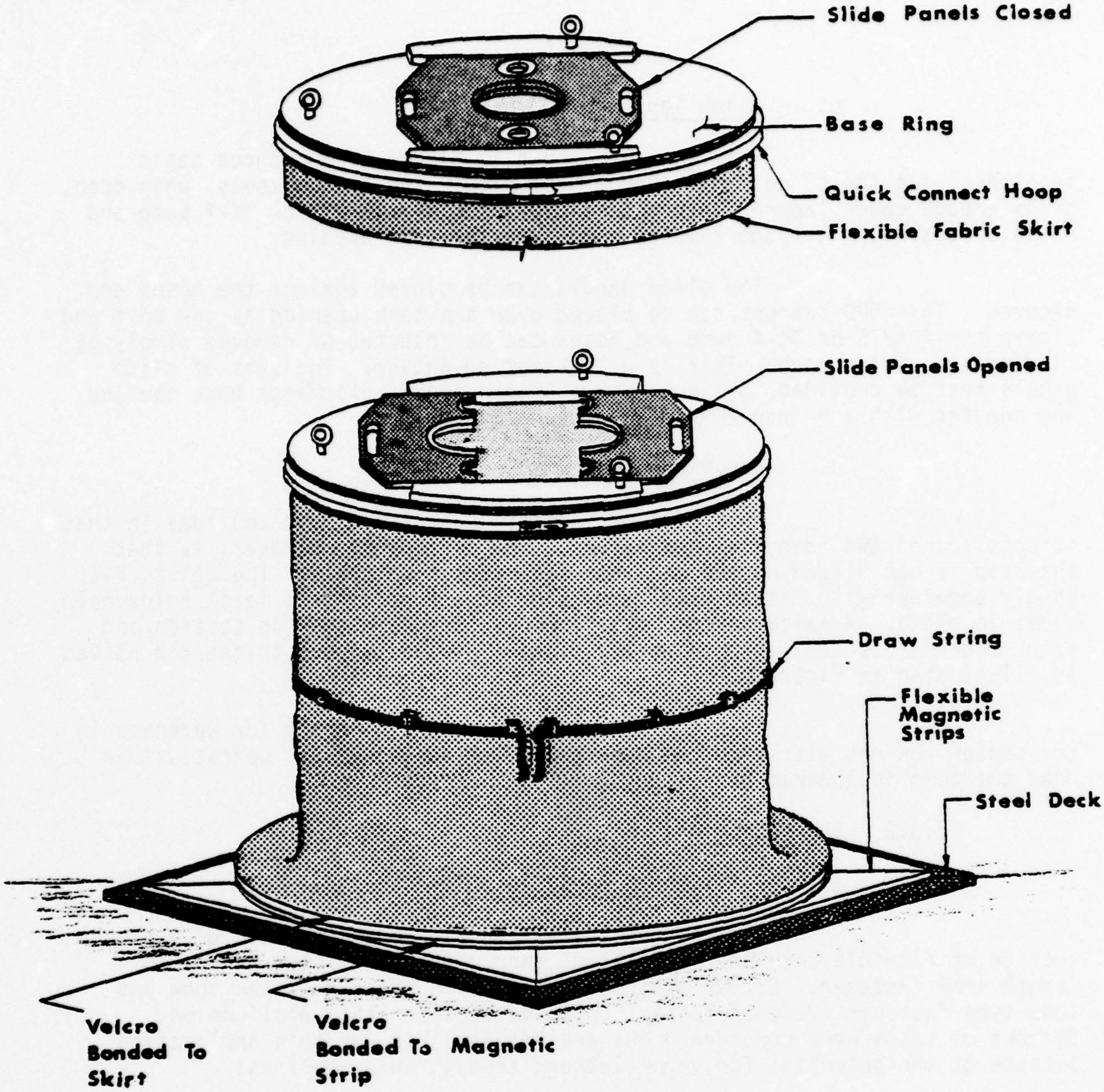
3.3.2 Skirt Section

a. Full-Length Open/Close Seam

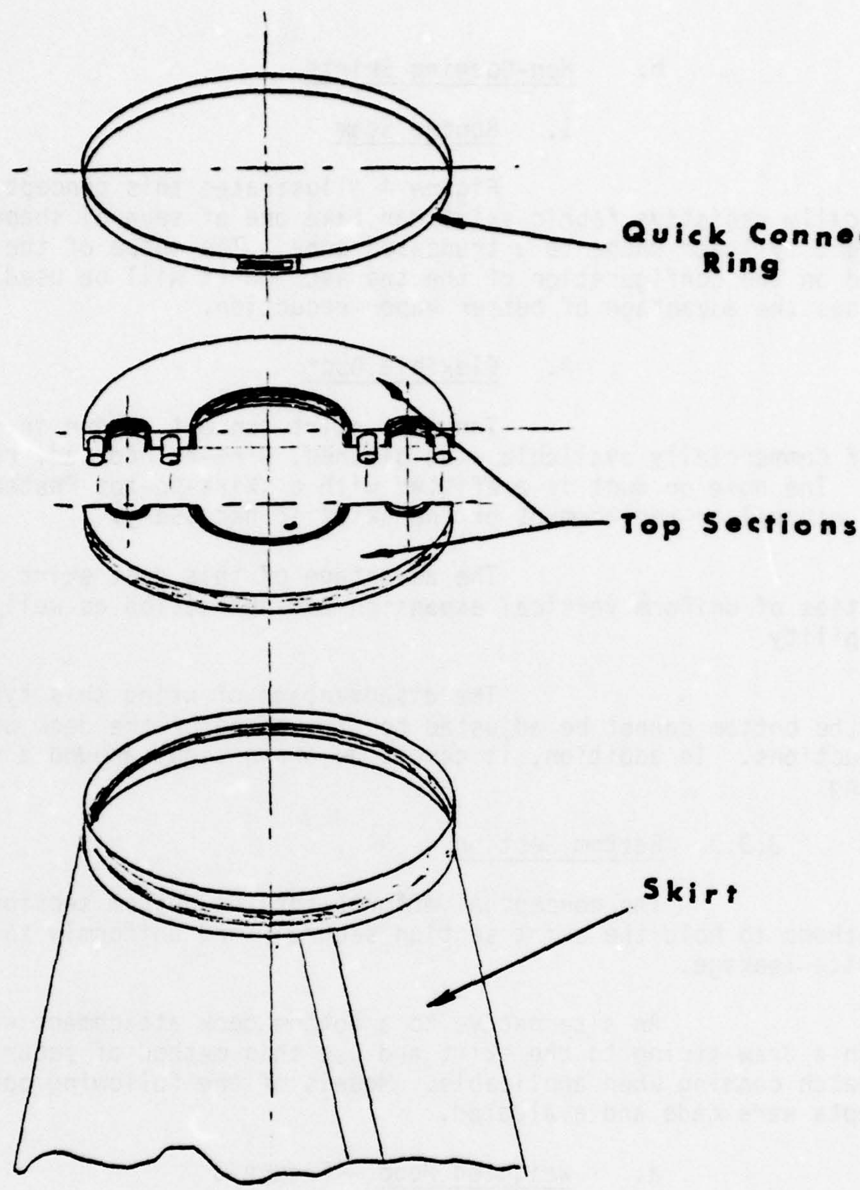
This concept, shown in Figure 3, consists of a single section of flexible chemically resistant fabric that is fitted with a full-length seam fastener. Either a zipper or a fabric press-together hook and loop-type fastener (Velcro) concept could be used for this application. Buttons or snaps were considered but are not feasible for this application because of the potential for vapor leakage through seam openings.

The major advantage of an open/close seam is that it allows skirt removal or replacement without removing the pump if the situation requires.

It should be noted that, regardless of the shape or diameter of the top section, the skirt would be made to fit it and the bottom would be cut to a size large enough to cover the largest deck opening, approximately 30 inches in diameter.



SLIDE TOP CONCEPT
With Velcro Fastened To Magnetic Strips
Fig. 5



Two Piece Top

Fig. 6

b. Non-Opening Skirts

1. Bonded Seam

Figure 4 illustrates this concept. The flexible, chemically resistive fabric skirt can take one of several shapes from a straight cylinder shape to a truncated cone. The shape of the skirt will depend on the configuration of the top section it will be used with. A bonded seam has the advantage of better vapor reduction.

2. Flexible Duct

The duct skirt concept, shown in Figure 7, makes use of commercially available wide-pitched, wire-reinforced, retractable hose. The hose or duct is prefitted with a skirt-to-top fastening hoop for quick removal or replacement of the skirt if necessary.

The advantage of this duct skirt is that it has qualities of uniform vertical expansion and retraction as well as good bending flexibility.

The disadvantage of using this type of duct is that the bottom cannot be adjusted for the shape of the deck opening or deck obstructions. In addition, it cannot be drawn tight around a raised hatch coaming.

3.3.3 Bottom Section

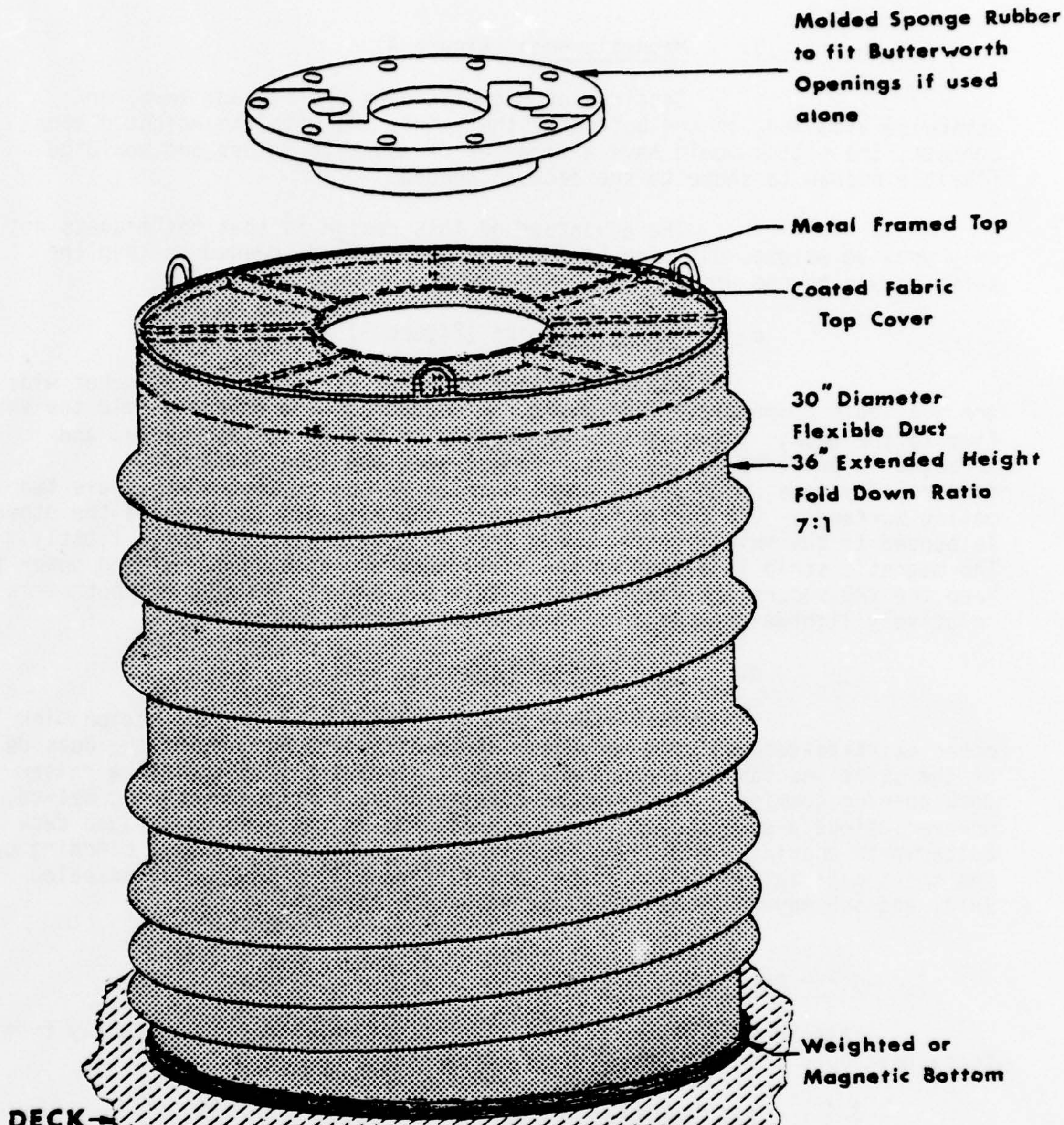
The conceptual efforts for the bottom section concentrated on methods to hold the skirt section securely and uniformly to the deck to minimize leakage.

An alternative to a bottom deck attachment would be to attach a draw-string to the skirt and use this method of securing directly to the hatch coaming when applicable. Models of the following bottom section concepts were made and evaluated.

a. Weighted Hoop - Figure 3

Lead shot was inserted into a flexible plastic tube approximately 1 inch in diameter. The tube was sealed and the ends joined to form a ring or hoop with a diameter of approximately 30 inches. This hoop was sewn into the skirt bottom.

The disadvantage of this concept was that it lacked good positive holding power to keep the VRD securely to the deck.



Frame Top Concept with Flexible Duct Skirt

Fig. 7

b. Magnetic Hoop (Figure 4)

Sections of magnetic bars are fitted, sewn, or otherwise attached, to the bottom of the skirt. As with the weighted hoop concept, the bottom would have a diameter of about 30 inches and would be flexible enough to shape to the deck as needed.

The advantage of this design is that the magnets not only provide weight, but also have the hold-down force needed to keep the skirt secure to the deck.

c. Magnetic Strips (Figure 5)

Flexible magnetic rubber strips up to 18 inches wide are available commercially and yield the needed holding power to hold the VRD firm to the deck. These strips can readily be cut to various shapes and arranged in patterns on the deck. Fabric hook and loop fasteners, commercially made under patent names such as Velcro or Scotchmate, have two mating surfaces. One surface is bonded to the magnetic strip while the other is bonded to the skirt bottom. When pressed together, they fasten tightly. The magnetic strip is placed on the steel deck and gives good holding power to keep the VRD secure and vapor tight. This concept of securing the bottom is relatively lightweight compared to other considered concepts.

d. Draw String (Figure 5)

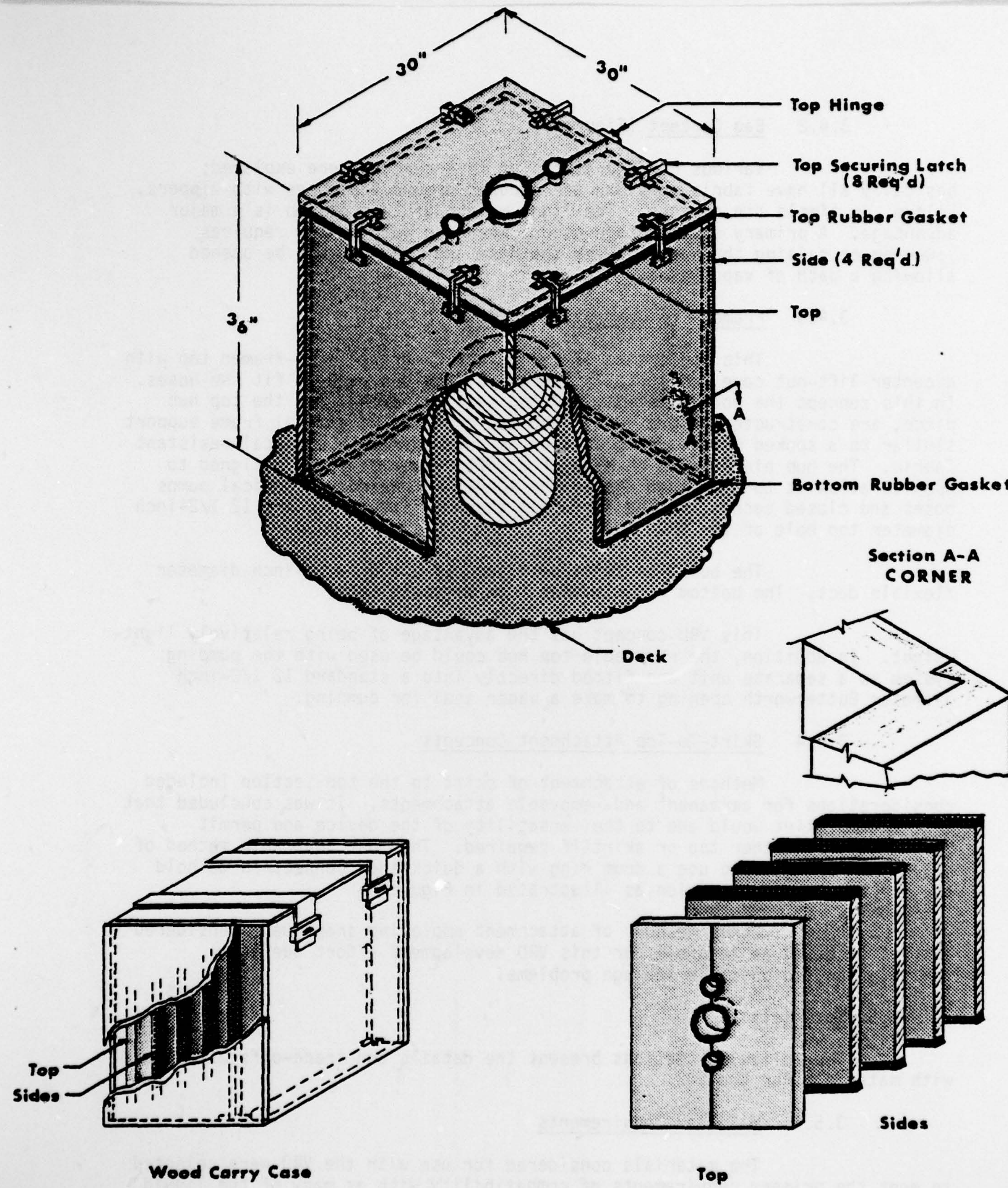
This simple concept can be used in conjunction with other skirt-to-deck holding concepts. A cord is attached around the outside of the skirt and can be drawn tight to pull the skirt snug against a raised deck opening coaming. It cannot be considered as a primary securing method, however, since a skirt-to-deck seal is required in the case of a flush deck Butterworth opening. Additionally, there is the possibility that cinching up the skirt material around a raised deck fitting will allow small, unsealed voids and subsequent paths for vapor to escape through.

3.4 Other Considered Concepts

This section presents various concepts which deviate slightly from those developed from the specific requirements.

3.4.1 Box Concept

This concept, Figure 8, consists of four sides and a top section. The top is designed similar to other tops and is hinged to fit around the hoses. This box could be made of wood, broken down into flat sections for packaging, and transported very readily. The main disadvantage of this design is that the box is too rigid and could not be adjusted to the hose tilt direction.



BOX CONCEPT

Fig. 8

3.4.2 Bag Concept (Figure 9)

Various configurations of this concept were explored; basically all have fabric tops and are secured around the hoses with zippers, Velcro, or simple tie strings. The light weight of this design is a major advantage. A primary disadvantage occurs when the pump system requires lowering or raising the seal between the hose and the top must be opened allowing a path of vapor escape.

3.4.3 Framed Top Concept (Figure 7)

This concept calls for a fabric-covered wire-framed top with a center lift-out core section. The core would be designed to fit the hoses. In this concept the bottom, skirt, and top section, except for the top hub piece, are constructed as one unit. The top consists of a metal frame support similar to a spoked wheel. This section is covered with a chemical-resistant fabric. The hub piece would be made of a soft rubber material designed to open to allow it to be fitted around the ADAPTS or hazardous chemical pumps hoses and closed securely. The hub would then be fitted into the 12 1/2-inch diameter top hole of the VRD.

The built-on skirt section consists of a 30-inch diameter flexible duct. The bottom ring is made from magnetic bars.

This VRD concept has the advantage of being relatively light-weight. In addition, the removable top hub could be used with the pumping system as a separate unit and fitted directly into a standard 12 1/2-inch diameter Butterworth opening to make a vapor seal for pumping.

3.4.4 Skirt-To-Top Attachment Concepts

Methods of attachment of skirt to the top section included considerations for permanent and removable attachments. It was concluded that a removable skirt would add to the versatility of the device and permit replacement of either top or skirt if required. The most adaptable method of doing this would be to use a drum ring with a quick-snap connection to hold the skirt to the top section as illustrated in Figure 4.

Other methods of attachment employing snaps were considered but not accepted as feasible for this VRD development effort due to manipulation and possible leakage problems.

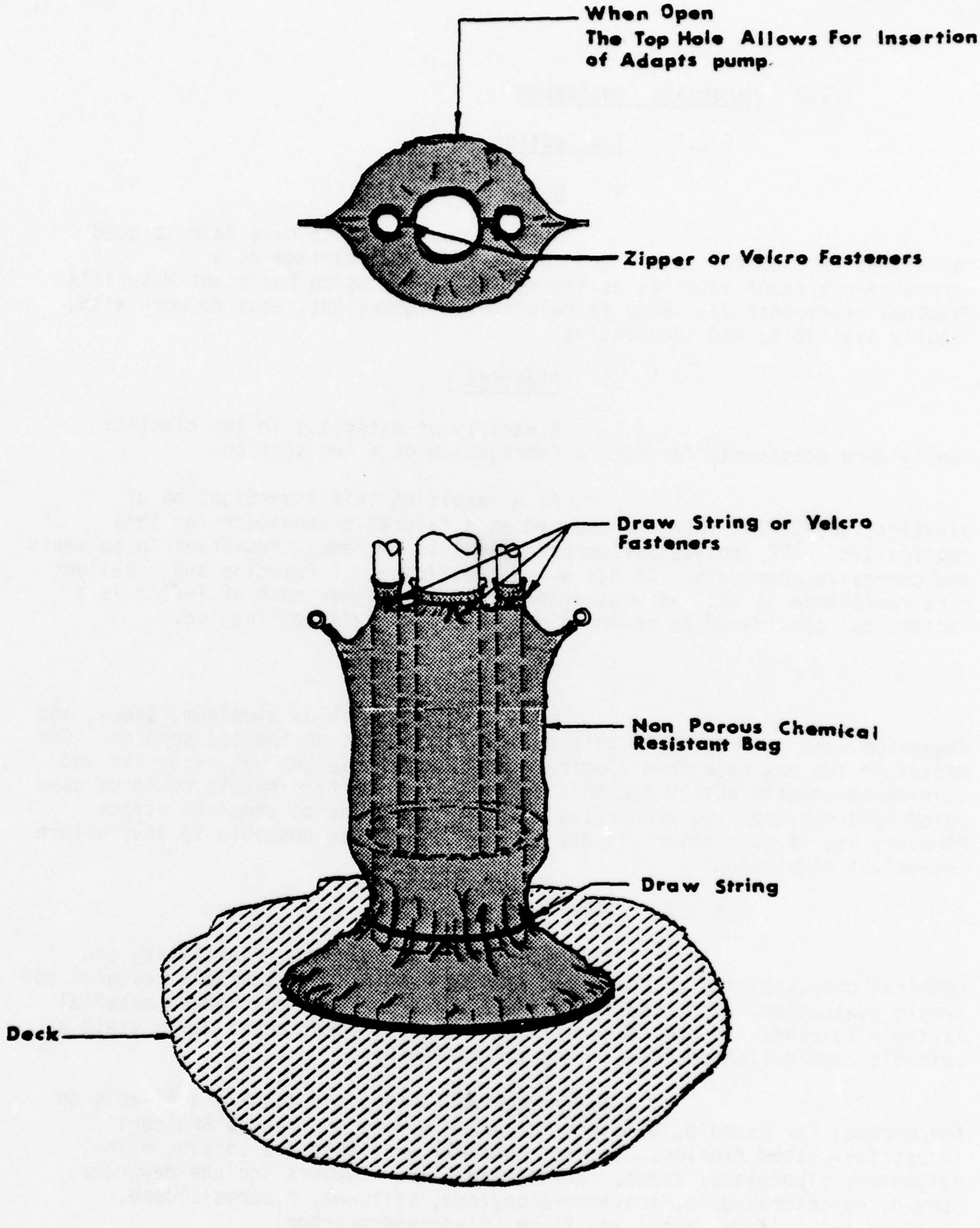
3.5 Materials

The following sections present the details and trade-offs associated with materials for the VRD.

3.5.1 Material Requirements

The materials considered for use with the VRD were selected to meet the primary requirements of compatibility with as many of the liquid chemicals as possible listed in the CHRIS Manual.

Other requirements are the flexibility of the skirt materials and the strength of all materials used in fabrication of the VRD.



DRAW STRING BAG CONCEPT

Fig. 9

3.5.2 Materials Considered

3.5.2.1 Top Section

a. Wood

Wood is considered to have fair to good resistance to chemical attack and can be used to advantage as a corrosion-resistant material as stated in the Corrosion Resistant Materials Handbook (reference 7). Wood is relatively lightweight, easy to work with, readily available, and inexpensive.

b. Plastics

A variety of materials in the plastics family were considered for use in fabrication of a top section.

As a result of this investigation of plastics, TFE-Teflon (DuPont) emerged as a favorable candidate for this application. TFE (polytetrafluoroethylene) is extremely resistant to solvents and corrosive chemicals. It has a low coefficient of friction and excellent fire resistance as well as weatherability. The higher cost of Teflon is a factor, but considered to be not significant for this application.

c. Metals

Various metals such as aluminum, steel, and magnesium were considered in this development effort on the top section. One prototype top was made from aluminum; however, the weight was excessive and considered unsatisfactory for this application. Certain metals could be used which have non-sparking properties and are impervious to chemical attack. However, use of such materials was avoided as much as possible to stay within the weight requirements.

3.5.2.2 Skirt Section

The requirement of strength, flexibility and chemical compatibility of the skirt section required considerable research and sample evaluation. The results indicated that a fabric reinforced material having a thickness in the range of .008 inches to .020 inches would yield a suitable combination of flexibility and strength.

Rubber-coated fabrics are readily available on the market; for example, DuPont's Fairprene series and Reeves Brothers' industrial-coated fabrics. Fabrics commonly available are cotton, nylon, polyester, fiberglass, rayon, teflon, and silk. Rubbers include neoprene, buna-N, epichlorohydrin, ethylene-propylene, silicone, fluorosilicone, urethane polysulfide, butyl and Viton (fluorohydrocarbon).

The most chemical-resistant of the rubbers considered is Viton. Many of the relatively few chemicals which attack Viton are resisted by butyl rubber which, however, is poor for hydrocarbons. This

is demonstrated on the chart (Figure 10) which shows the resistance of various rubbers to chemicals with a spill history from 1973-78 (documented in the PIRS; Pollution Incident Reporting System). This chart shows the advantages provided by a system of skirts employing more than one material.

Consideration of a greater range of bulk liquid chemicals (reference 4) shows up more dramatically the complementary use of Viton and butyl rubber, the latter being resistant to low molecular weight organic acids, esters, ketones, and amines which attack Viton. Neoprene, which is much less expensive than Viton, has fair all-around chemical resistance. A recent study for NIOSH (reference 5) on the permeation of a number of carcinogenic liquids through various protective suiting materials indicates that Viton is superior, followed by butyl rubber. Neoprene has fair all-around resistance to permeation.

Some information on short-term chemical resistance of urethane, neoprene, buna-N, fluorohydrocarbon, butyl and ethylene-propylene rubbers is given in reference (7).

3.5.2.3 Bottom Section

a. Weighted Ring (Figure 4)

This concept makes use of a weighted flexible ring or tube to hold the VRD flush to the deck. It makes use of lead shot or metal nuggets held in a one-inch diameter plastic tube and sewn to the bottom of the skirt section.

b. Magnets

Ceramic or alnico magnetic bars approximately 1-7/8" by 7/8" by 3/8" and fitted with a 0.056 thick steel sheet bonded to the top were considered as the attaching method to the bottom rim of the skirt. Each bar has a holding power of approximately five pounds. This method of deck attachment would allow for the skirt section and bottom section to be employed as one unit.

c. Magnetic Strips (Figure 4)

This concept makes use of magnetic rubber strips 18 inches wide and cut to lengths needed to cover the required deck area around a tank opening. One hundred percent polyester Velcro will be sewn to the top surface of the magnetic strip. The mating Velcro strip will be sewn onto the skirt bottom using 100 percent polyester thread. The Velcro used for this concept was recommended for its compatibility with chemicals.

3.6 Evaluation and Selection Of Concepts For Pre-Prototype

Shop models of various concepts of the top, skirt, and bottom sections were made to evaluate their feasibility for further development into a pre-prototype. From this evaluation, using the concept definition design parameters as basic criteria, the most desirable concept for each section was selected. The selection results are as follows:

Key:

A - Recommended - little or no effect
B - Minor or moderate effect
C - Moderate to severe effect
U - Not recommended
Blank - no data

CHEMICAL	RUBBER MATERIALS										2 RUBBERS		
	BUTYL	NEOPRENE	BUNA-N	HYPALON	FLUOROSILICONE	POLYSULFIDE	EPICHLOROHYDRIN	URETHANE	ETHYLENE PROPYLENE	VITON	VITON/BUTYL	VITON/NEOPRENE	VITON/BUNA-N
ACETIC ACID	B	C	C	C	C	B	U	U	A	C			
ACETIC ANHYDRIDE	B	A	C	A	U	B	U	U	B	U			
Acetone	A	B	U	B	U	C	U	U	A	U			U
ACRYLONITRILE	U	C	U	C	U	U			U	U	U		U
AMMONIA (28% aq)	A	A	U	A	B	U	B	A	A	B			
BENZENE	U	U	U	U	A	C	U	U	U	A			
CAUSTIC SODA	A	A	B	A	B	U	B	B	A	B			
Copper Comp.	A	B	B	B	A	U		A	A	A			
CRESOLS	U	C	C	C	B	U		U	U	A			
CYCLOHEXANE	U	U	A	U	A	A		B	U	A			
ETHYL ACETATE	B	C	U	C	U	B	U	U	B	U			
ETHYL ACRYLATE	B	U	U		U	B	U		B	U		U	U
ETHYL ALCOHOL	A	A	A	A	A	A	A	B	A	A			
ETHYLENE DIAMINE	A	A	A	A	U		A		A	U			
Ethylene Dichloride	C	U	U	U	C	U	U	U	C	A			
HEXANE	U	B	A	B	A	A	A	B	U	A			
HYDROCHLORIC ACID	A	B	B	A	B	U	U	U	A	A			
ISOPROPYL ALCOHOL	A	A	B	A	B	A	A		A	A			
METHYL ACRYLATE	B	B	U		U				B	U			U
METHYL ALCOHOL	A	A	A	A	A	B	B	U	A	C			
Methyl Ethyl Ketone	A	U	U	U	U	A	U	U	A	U		U	U
NAPHTHALENE	U	U	U	U	A	B		B	U	A			
NITRIC ACID (conc)	C	C	U	B	U	U	U	U	C	A			
OLEUM	U	U	U	U	U	U	U	U	U	A			
PHENOL	B	C	U	C	B	U		U	B	A			
PHOSPHORIC ACID	B	B	U	B	B	U		A	B	A			
STYRENE	U	U	U	U	C				U	B			
SULFUR	A	A	U	A	A	U	C		A	A			
SULFURIC ACID (dilute)	B	B	U	A	C	U	B	B	B	A			
TOLUENE	U	U	U	U	B	U	U	C	U	A			
TURPENTINE	U	U	A	U	B	B	A	U	U	A			
VINYL ACETATE	B	U	U	U		U	U		U	U		U	U
XYLENE	U	U	U	U	A	B	U	C	U	A			
Xylenol	U	C	C	C	B			U	U	A			

Compatability Data for
VRD Skirt Material

Fig. 10

3.6.1 - Top Section - The slide cover top was selected, primarily because the design allows for the ADAPTS and hazardous chemical pump and hoses to be inserted or removed after the VRD is set in place over a tank opening as one unit. This advantage is not found in other concepts considered in the development effort. Teflon was selected as the material to be used for this slide top because it is rated high for chemical compatibility and durability.

3.6.2 - Skirt Section - As a result of data evaluation, viton-coated dacron was selected for the skirt material to be used on the pre-prototype and prototype due to its overall superiority for chemical resistance. Ideally, production models of the VRD should be made with viton, butyl rubber, and neoprene skirts material to allow for a system of skirts.

In this manner, virtually all liquid chemicals would be covered and the compatibility of the entire VRD system would be equivalent at all times to the chemically impervious teflon/stainless steel top section of the VRD.

- The bonded seam concept and the open/close zipper concept have distinct advantages and both will be considered for use for pre-prototype and prototype evaluation.

3.6.3 - Bottom Section - The magnetic rubber strip with Velcro combination for deck attachment appears to give the most versatility of use and assurance of firm, flush, hold-down power for the VRD.

3.7 Pre-Prototype Demonstration

Coast Guard R&D Center personnel demonstrated the selected pre-prototype concept of the VRD to Headquarters (G-DOE and G-EOE) representatives and personnel from the three Coast Guard Strike Teams. Demonstrations of all components were conducted at both Panama City, Florida and at the Gulf Strike Team Headquarters at Bay St. Louis, Mississippi, during the period from 27 March to 3 April 1979.

The demonstrations served to critique this concept and gain first-hand knowledge and constructive input for further changes or modifications in the development of the prototype. Several hardware and material components that were shown varied slightly from those shown on the detailed drawings (Appendix A), but this did not deter from the concept evaluation effort.

The VRD demonstration package consisted of:

30-inch Slide Top	Appendix A-1
30-inch Skirt Section	Appendix A-2
Skirt-to-Top clamp device	Appendix A-3
Magnetic Deck Attachment Mat	Appendix A-4
24-inch Slide Top (wood model)	Appendix A-5

The demonstration included actual insertion of the pumping systems through the pre-prototype top section. Both the Coast Guard ADAPTS pump and hoses and the Framo TK-4 chemical pump and hoses were used in this demonstration.

The slide top concept was designed with versatility to accommodate either the ADAPT 6-inch discharge hose or the TK-4 4-inch diameter discharge hose simply by changing the top slides to fit the application. The design aspects of the top section were further evaluated by observing the device during pump and hose manipulation when moved up and down simulating pump positioning, as would be the case during actual cargo tank pumping operations. The top components worked well.

In addition, the VRD skirt section and bottom magnetic strip hold-down section demonstration yielded constructive recommendations from observing CG personnel. These recommendations were considered in the fabrication of a prototype model.

4.0 PRE-PROTOTYPE EVALUATION SUMMARY

The pre-prototype concept of the slide top received general acceptance with favorable comments and, as a result of the demonstration, the following constructive comments and suggestions were recorded.

1. The weight of the device was satisfactory and the 40 lb. top section would pose no problem in handling under actual offloading operations.

2. The 2-inch hydraulic hose holes in top, as well as the 6-inch discharge hose hole, proved to be too large and it was recommended that the diameters be reduced on these openings by 1/4 inch. The 4-inch TK-4 discharge hose hole was satisfactory.

3. The gasket material used to encircle the hoses to minimize the vapor leakage was not thick enough and lacked rebound (elastic) qualities needed for a good seal. It was recommended that the gasket thickness be increased or another material be considered for this application.

4. The sturdiness of the VRD was very satisfactory under testing conditions. Distortion was minimal under forces and did not prohibit operation of the top slides.

5. It was recommended that the skirt be 48-inches long from deck to top of skirt with an attached 12-inch flap around the bottom circumference for deck attachment.

6. Suggestions for drawing the skirt tight around raised hatch coamings were made and were used on the prototype model. The side seam fastening methods received evaluation as well as no-seam skirts. Both methods and designs were further investigated. The use of Velcro or zippers for side seam sealing was discounted after it was tried and failed to be a practical method on this application.

7. A recommendation to replace the top flush-mounted fixtures to be used for tripod hookup with eye bolts for easier hook-on was accepted and was incorporated in the prototype design.

In conjunction with the development of the 30-inch top, a 24-inch model was made. The 24-inch slide top varies only slightly in design from the 30-inch concept. This model, shown during the demonstration, differed in that it housed both the 4-inch and 6-inch discharge hose slides together on the top section. The 30-inch top did not have this capability.

Enough interest was expressed in this design so that prototypes of both designs were fabricated for further evaluation. The 24-inch concept is shown in Appendix A-5.

5.0 PROTOTYPE FABRICATION

The suggested recommendations and changes received at the demonstration of the pre-prototype VRD, combined with additional CG R&DC materials research, served as the basis for the modifications made to produce a prototype model.

5.1 Modifications

The following hardware changes were made:

1. The hose hole openings in both the 30-inch and 24-inch diameter tops were reduced in diameter by 1/4 inch to give a better seal around the 2-inch hydraulic hoses as well as the 6-inch discharge hose. It was determined that the 4-inch chemical discharge hose hole did not require this change.

2. For the prototype model the gasket material used on the hose openings was increased in thickness from .008 to .125 inches. This gasket material is Viton rubber and better meets the requirements of compatibility and flexibility as opposed to the Buna-N material used on the pre-prototype.

3. The skirt length was increased to 48 inches from deck to top section. A separate section was sewn on the bottom to extend out along the deck approximately 12 inches. The velcro strips were sewn to this section to meet with the velcro on the magnetic deck strips.

4. Stainless steel eye bolts were installed in the top section to replace the recessed handles that proved hard to grasp and hook on to. These eye bolts are easily accessable for tying of the top to the tripod.

5. The use of zippers for skirt removal was not pursued on the prototype model as it was decided that the skirt section was an expendable item of the device and could be readily replaced with a non-open/close seam on scene if required.

6. Brass gasket retainers used on the pre-prototype model top section lacked resistance to certain chemicals and were replaced with 16 gage stainless steel plates for better compatibility on the prototype model.

6.0 VAPOR REDUCTION EFFECTIVENESS TEST

A test plan was developed and tests were conducted to measure vapor concentration levels at several stations around a simulated tank opening.

Data was recorded with and without the VRD set in place over the opening. This was done to determine relative levels of vapor concentration to conclude a reasonable preliminary effectiveness factor for the VRD.

6.1 Approach

A simulated tanker deck with tank openings was constructed for development of the VRD at R&DC in Groton. This stage was also conveniently used for the tests. A diagram of the simulated tanker deck is shown in Figure 11.

The tanker deck platform was built over an existing empty steel frame pool about 2 meters deep. Chemical vapor was produced by evaporation of a liquid chemical (heptane) from a shallow tray placed within the tank opening about ten centimeters below its rim. Heptane was selected because of its ready availability, low toxicity and similarity to benzene with regard to evaporation rate and vapor density (benzene is one of the most hazardous substances likely to be handled by the Coast Guard Strike Teams).

Preliminary measurements (using a portable organic vapor analyzer (OVA)) of vapor concentration in stagnant air in the vicinity of the opening were rather erratic as the vapor appeared to be wafted about in random eddies. Steadier results were obtained when an air fan was placed to the side or below the opening. Threshold Limit Values (TLV) of vapor concentration (for liquid chemicals of interest) likely to be encountered can be as low as one part per million. Therefore, it is desirable that the VRD not permit vapor concentrations to rise above this level.

Vapor concentrations at a number of points around the tank opening were measured with the (OVA) to give a vapor plume profile. The test was then repeated with the VRD installed in place.

6.2 Procedure

A Century Systems Corporation organic vapor analyzer, model OVA-128, in the "survey mode" (Figure 12) was employed for this test. The instrument can detect heptane at a level less than one part per million and was calibrated for this experiment.

Liquid heptane was poured into the tray which is about a quarter of a square meter in area. An air fan about two meters to the side and blowing towards the tank opening was switched on and measurements of vapor concentration made at several points around the opening up to a distance of about three meters away horizontally and two meters vertically. The test was then repeated with the air fan placed about two meters below and blowing upwards to the opening.

In the course of the experiment, the background level of vapor increased by about 20 parts per million per hour which necessitated periodical zeroing of the analyzer at the fan. To ascertain that the slow increase in background concentration did not invalidate the results, measurements were taken over a sufficiently long period of time.

6.3 Materials and Equipment

Heptane was used as the chemical for vapor testing.

Equipment comprised of the organic vapor analyzer, an air fan of the simple box type used for room ventilation, an anemometer to measure wind speed and a thermometer.

6.4 Safety Considerations

The chief safety consideration arises from the explosive properties of heptane, the flammable limits for which are 1.05% and 6.7% by volume.

Precautions were therefore taken to ensure that these concentrations were avoided, especially at the fan which is an ignition source. The high vapor density of heptane, 3.5, causes it to form high concentration pockets at low levels. However, preliminary tests determined that these concentrations were well below the explosive limits except immediately inside the tank opening.

6.5 Test Results

With the air fan in the first position, i.e., about two meters horizontally away from the opening, measurements were taken without the VRD installed (Figure 12). At the opening, on the side farthest from the fan and one meter from the deck, vapor concentration was 30-50 ppm while at one meter distance it had dropped to 20-30 ppm and at two meters was 10-20 ppm. The background vapor level was recorded at 2 ppm. With the VRD set in place over the tank opening, the above concentrations fell to within 1 ppm of the background level (Figure 13). The air velocity around the tank opening, as measured by a NAVAER AN/PMQ-3 wind measuring set, was about 5 knots.

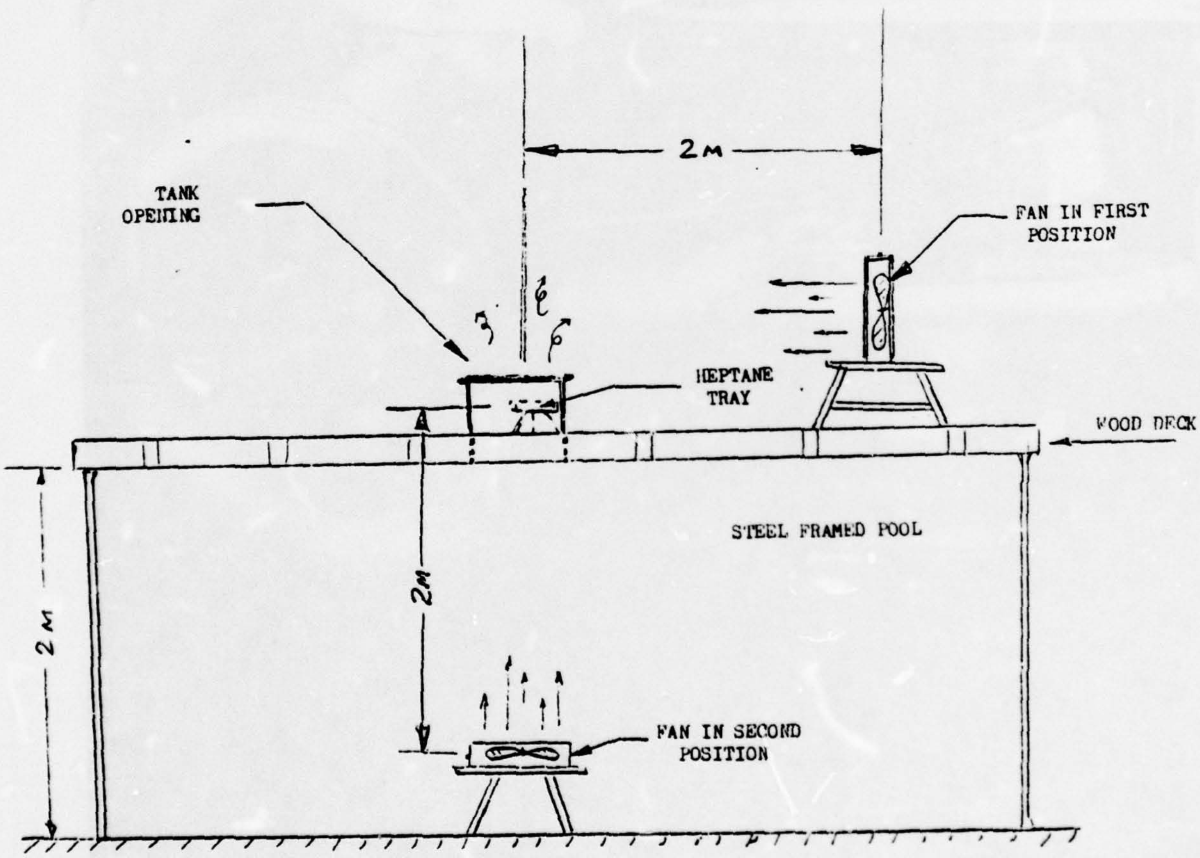
A second test was conducted with the air fan in the second position, e.g., about two meters below the tank opening and blowing upwards through it. Vapor concentrations recorded at the rim of the tank opening without the VRD ranged from 20-100 ppm, the highest value being at a position closest to the tray containing heptane. The tray was set to one side in the tank opening because of the ADAPTS hoses running through the tank opening. At one meter distance from the opening, at the one-meter level, concentrations varied from 2 to 20 ppm again depending on the position with respect to the tray. With the VRD employed, vapor concentration around the device again fell to within 1 ppm of the background level of about 3 ppm (Figure 14). The vapor concentration at the juncture of the gaskets around the hose opening on the VRD, and at certain points where the skirt attached to the top rim, indicated vapor leaks, but these were too small to have much effect on the general concentration level.

Air temperature during these tests ranged between 73-77^{o}F.

6.6 Conclusions

These tests indicate that the Vapor Reduction Device has the capability of keeping the vapor concentration levels around a tank opening below 1 ppm under the simulated conditions described.

TEST LOCATION BLDG. 37 CG R&D CENTER GROTON CT.



TEST DIAGRAM FOR
DETERMINING RELATIVE EFFECTIVENESS
OF VAPOR REDUCTION DEVICE

Fig. 11

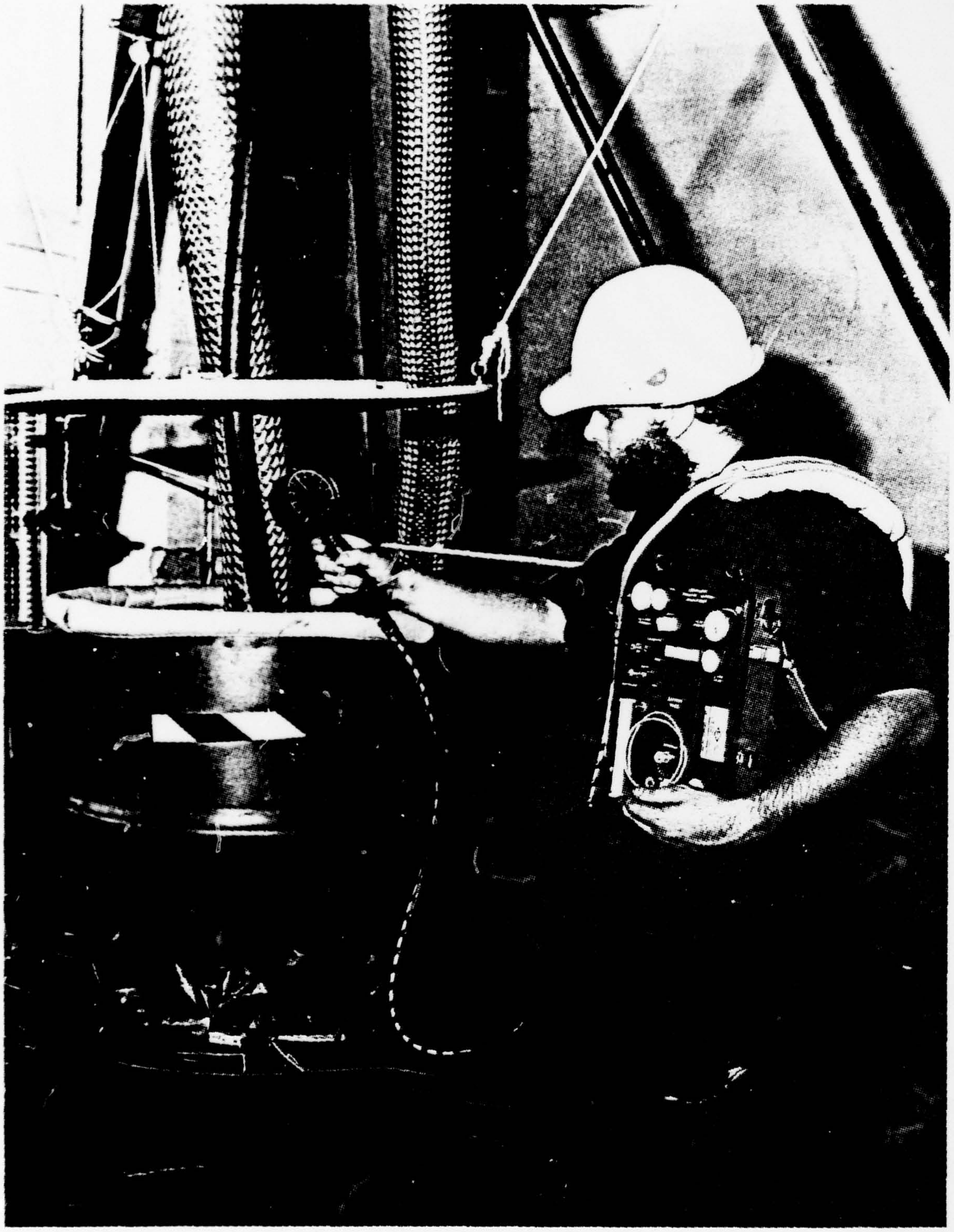


FIGURE 12. VAPOR MEASUREMENT WITHOUT THE SKIRT
FAN IN FIRST POSITION

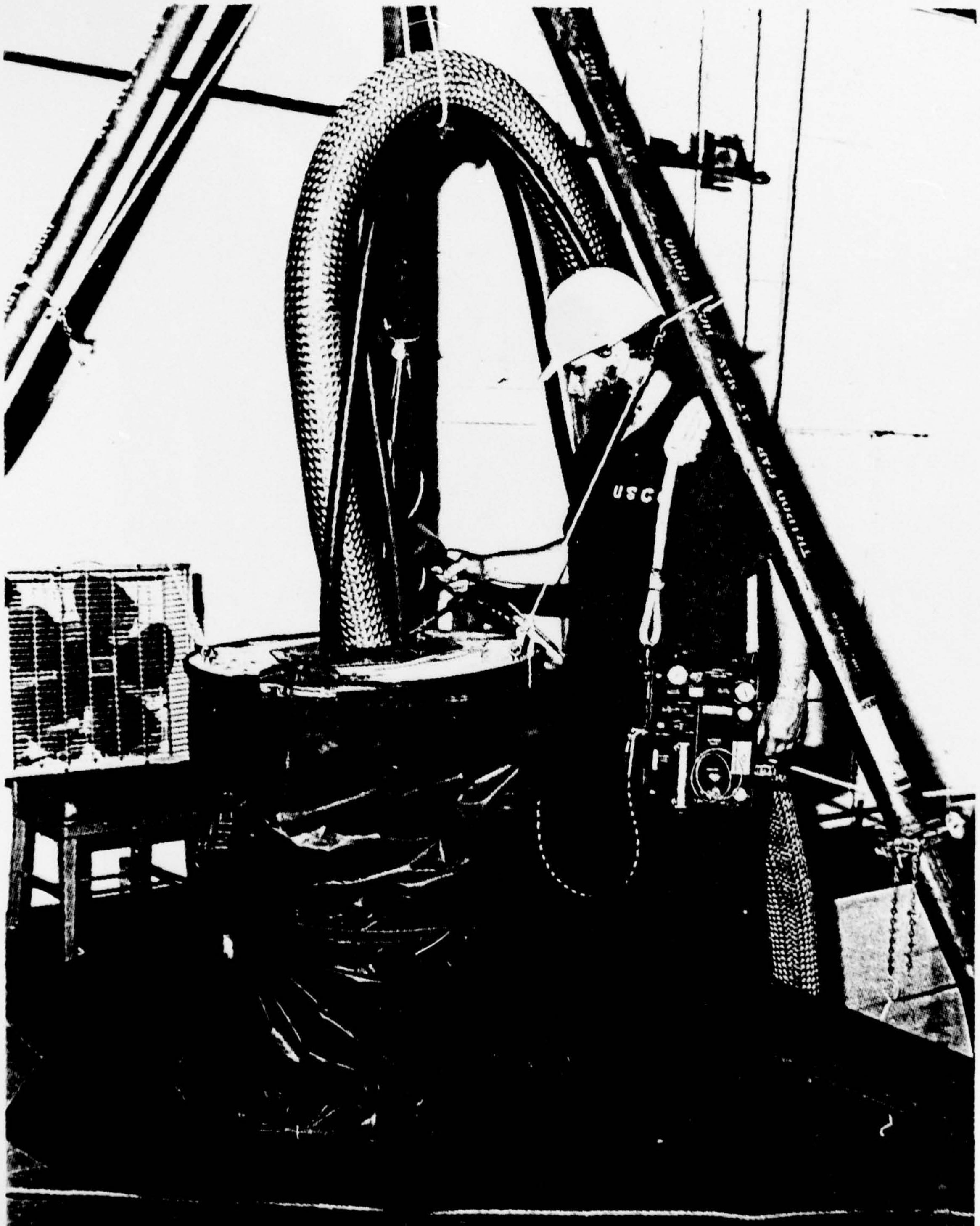


FIGURE 13. VAPOR MEASUREMENT WITH VRD SET IN PLACE
FAN IN FIRST POSITION

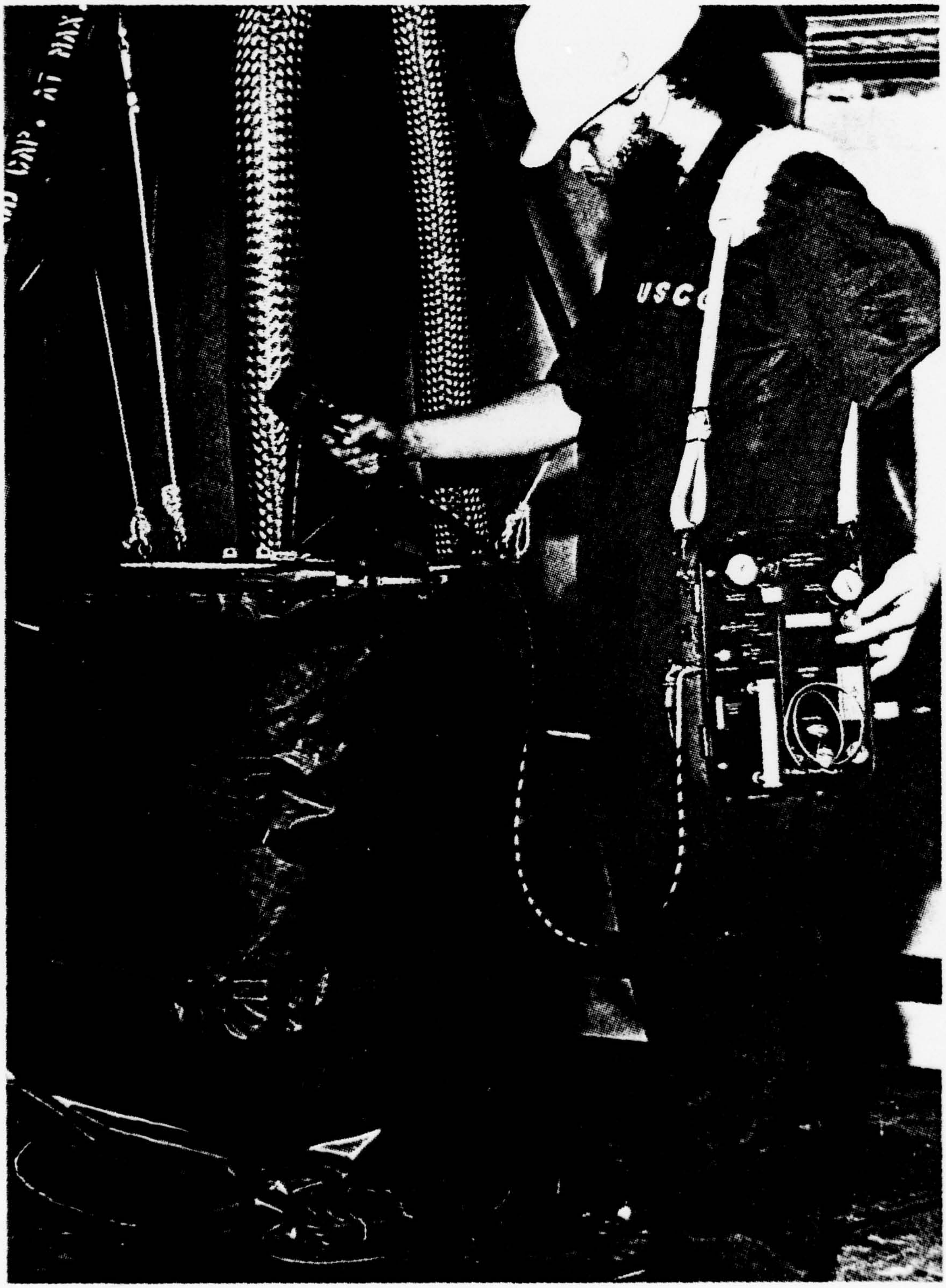


FIGURE 14. VAPOR MEASUREMENT WITH VRD SET IN PLACE
FAN IN SECOND POSITION

7.0 RECOMMENDED VRD SETUP PROCEDURE

1. Place magnetic mats on deck around tank opening with edges butted and the velcro facing up. (Figure 15)

2. Place VRD skirt and hoop over tank opening and press Velcro surface to matching deck surface. (Figure 16)

3. Suspend the top section from the tripod using tie-up attached to eye bolts on the VRD top. Height of top should be no more than 48 inches from deck. (Figure 17)

4. Raise skirt and connector hoop to fit around circumference of top section. (Figure 18)

5. Once hoop is set uniformly around edge of top clamp hoop in lock position. (Figure 19)

6. With top slides open, insert pump and hoses. Set position of hoses to allow for top slide closing. (Figure 20)

7. Close top slides securely against hoses and lock. (Figures 21, 22)

8. Use skirt draw strings around coaming of tank opening if applicable. (Figure 23)

9. The ADAPTS or Hazardous Chemical pump may be lowered without opening the slide top until such time as a hose coupling is encountered. Likewise the pump/hose combination can be raised without opening the slide top after preventers are attached from the VRD top to the deck hold down or to the base of the ADAPTS tripod.

10. Lead wool material can be used very effectively to further reduce vapor by packing strips of the lead wool around the Viton gaskets through which the discharge and hydraulic hoses pass.

11. The Viton gasket material may wear after several uses (particularly when used with the stainless steel hazardous chemical hose). These gaskets can readily be made from procured material and replaced at will.

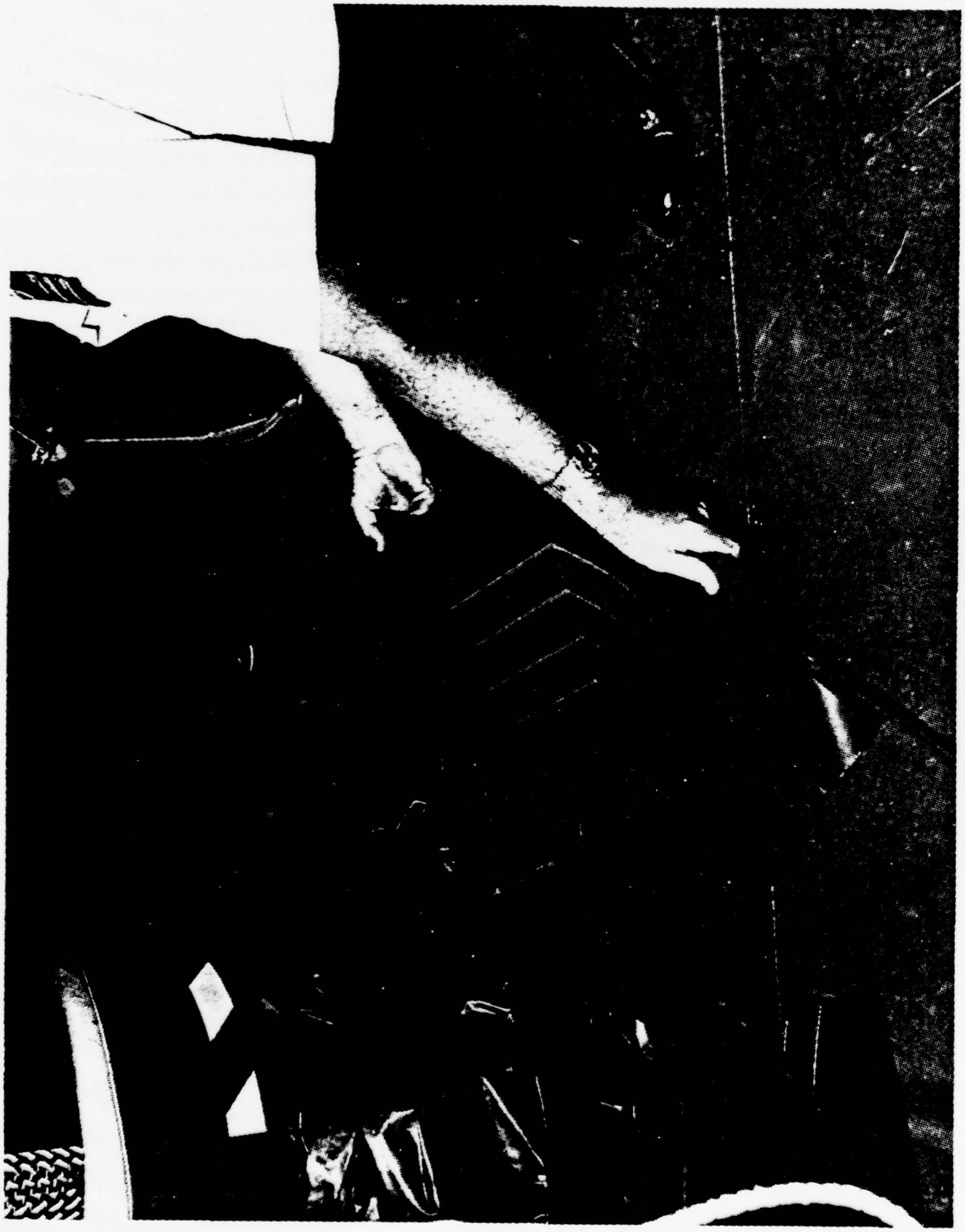


FIGURE 15. MAGNETIC DECK MATS WITH VELCRO STRIPS

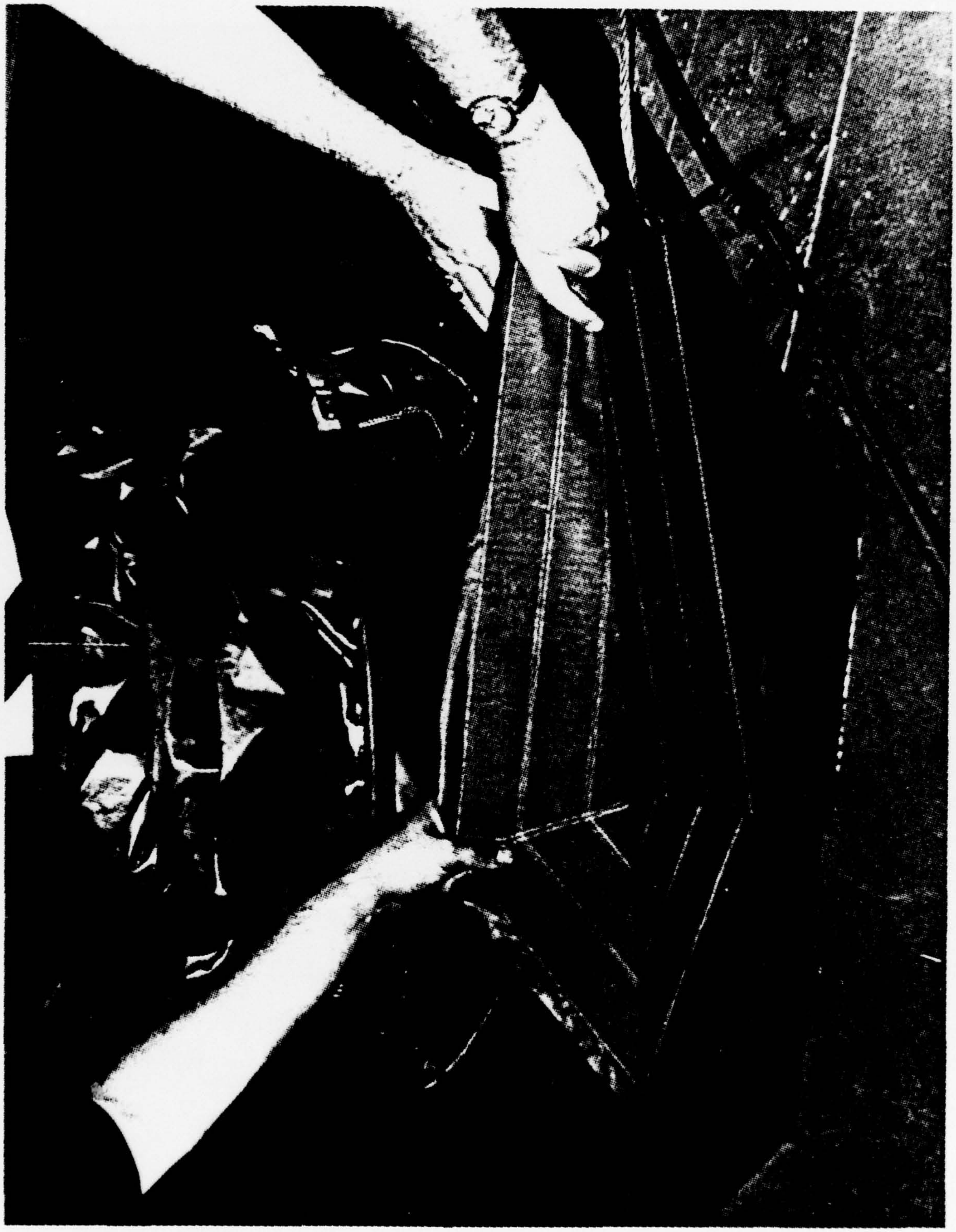


FIGURE 16. VRD SKIRT AND HOOP OVER TANK OPENING

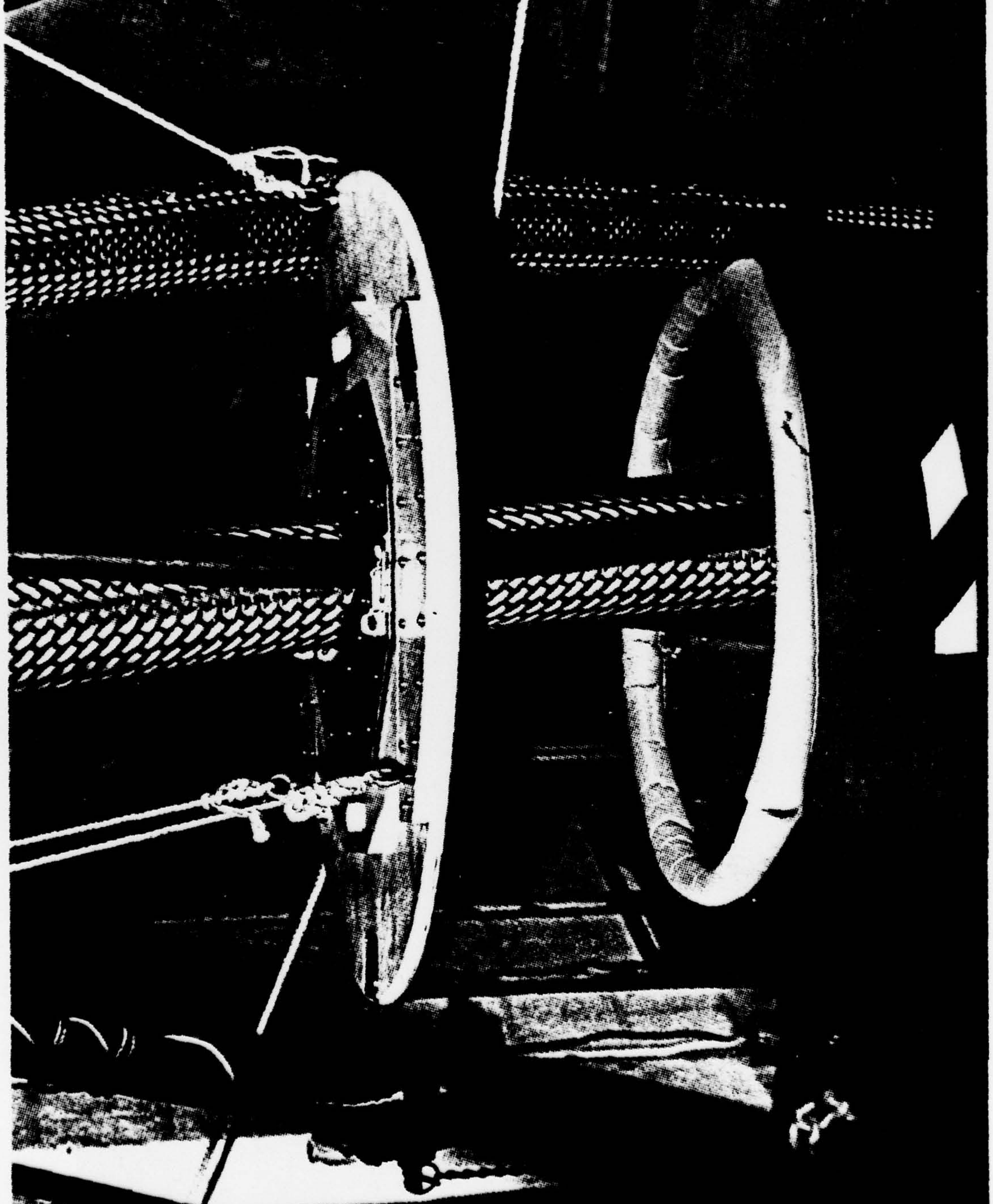


FIGURE 17. TOP SECTION SUSPENDED FROM TRIPOD

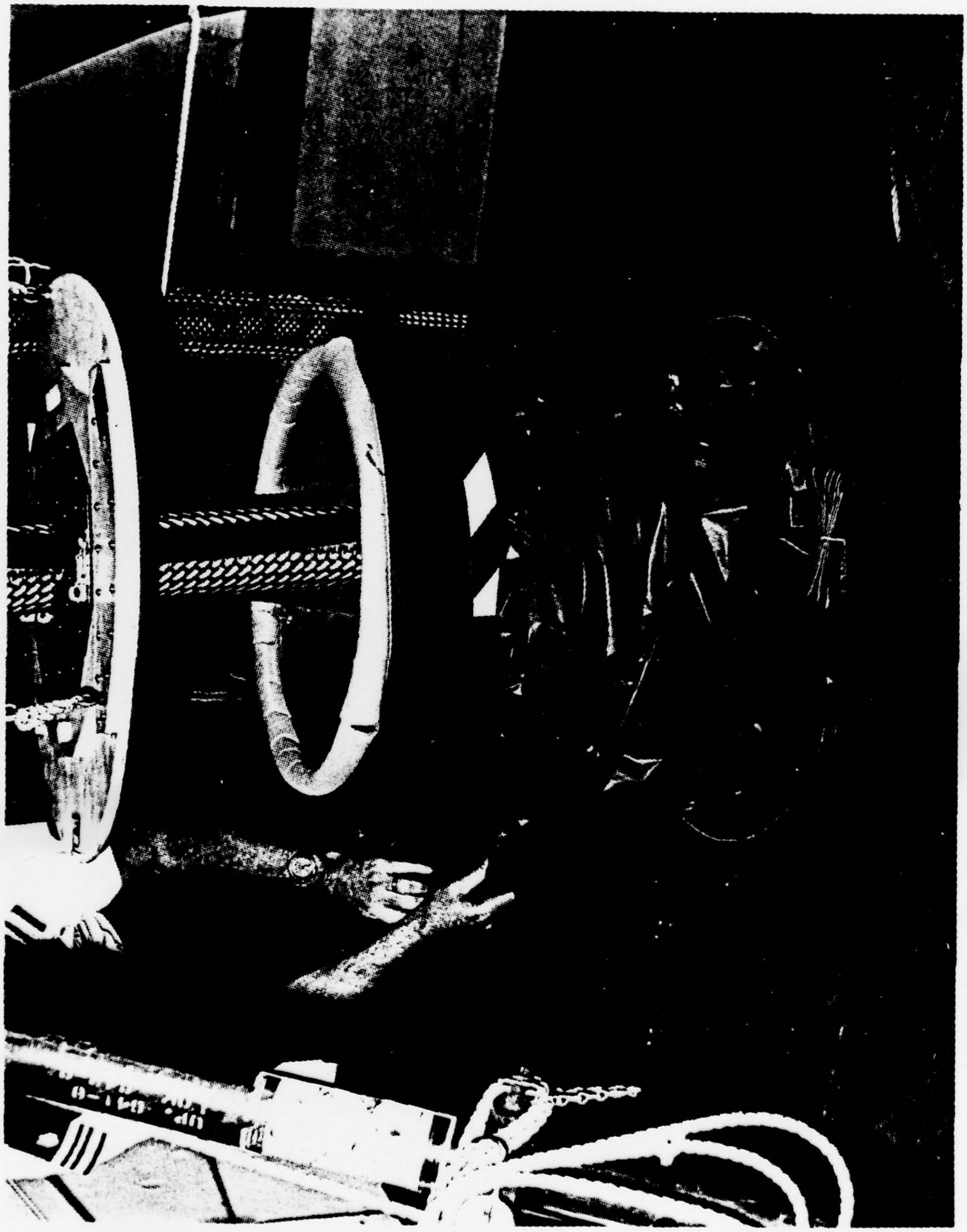


FIGURE 18. VRD SKIRT AND HOOP BEING RAISED

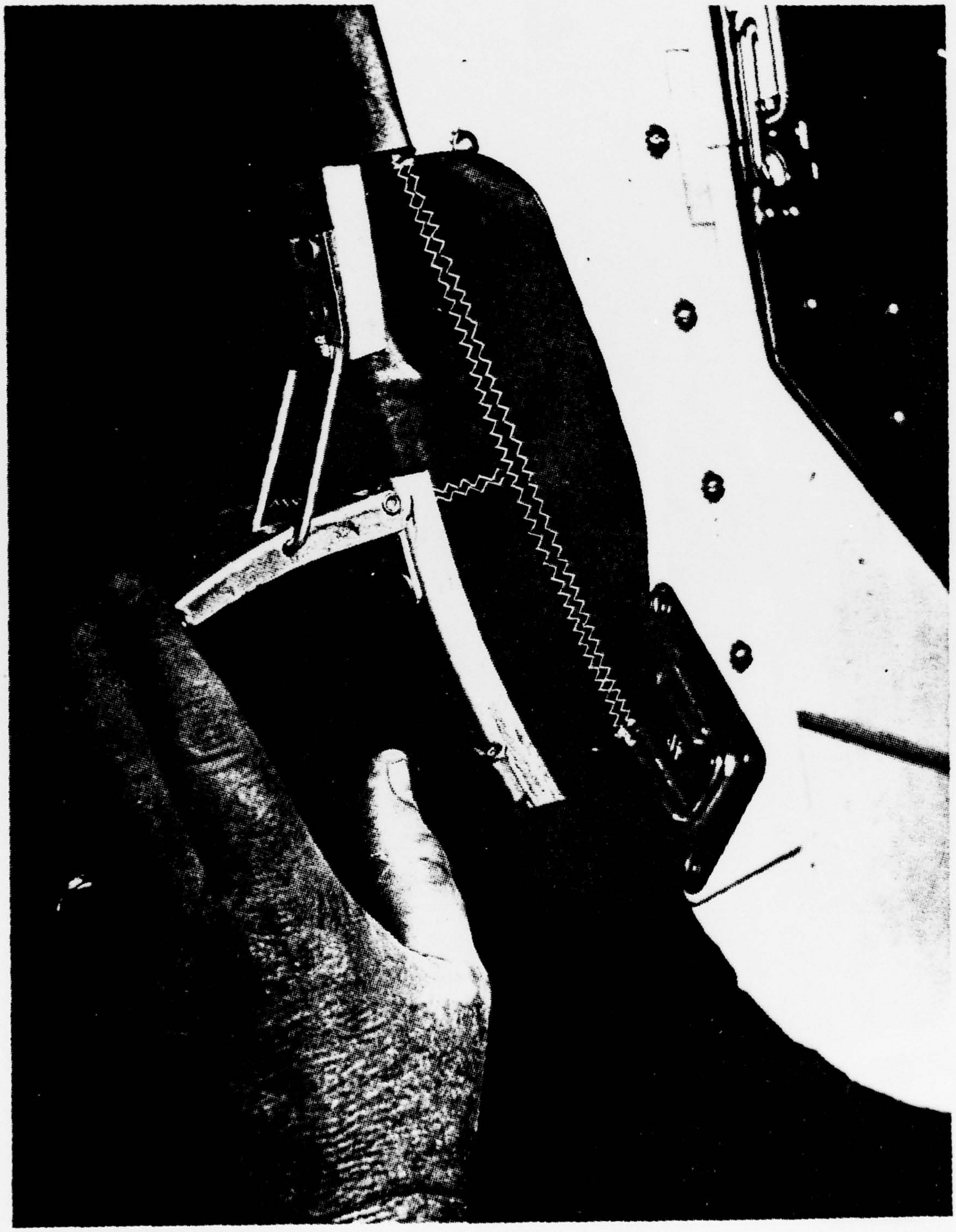


FIGURE 19. SKIRT AND HOOP LOCKED TO TOP SECTION

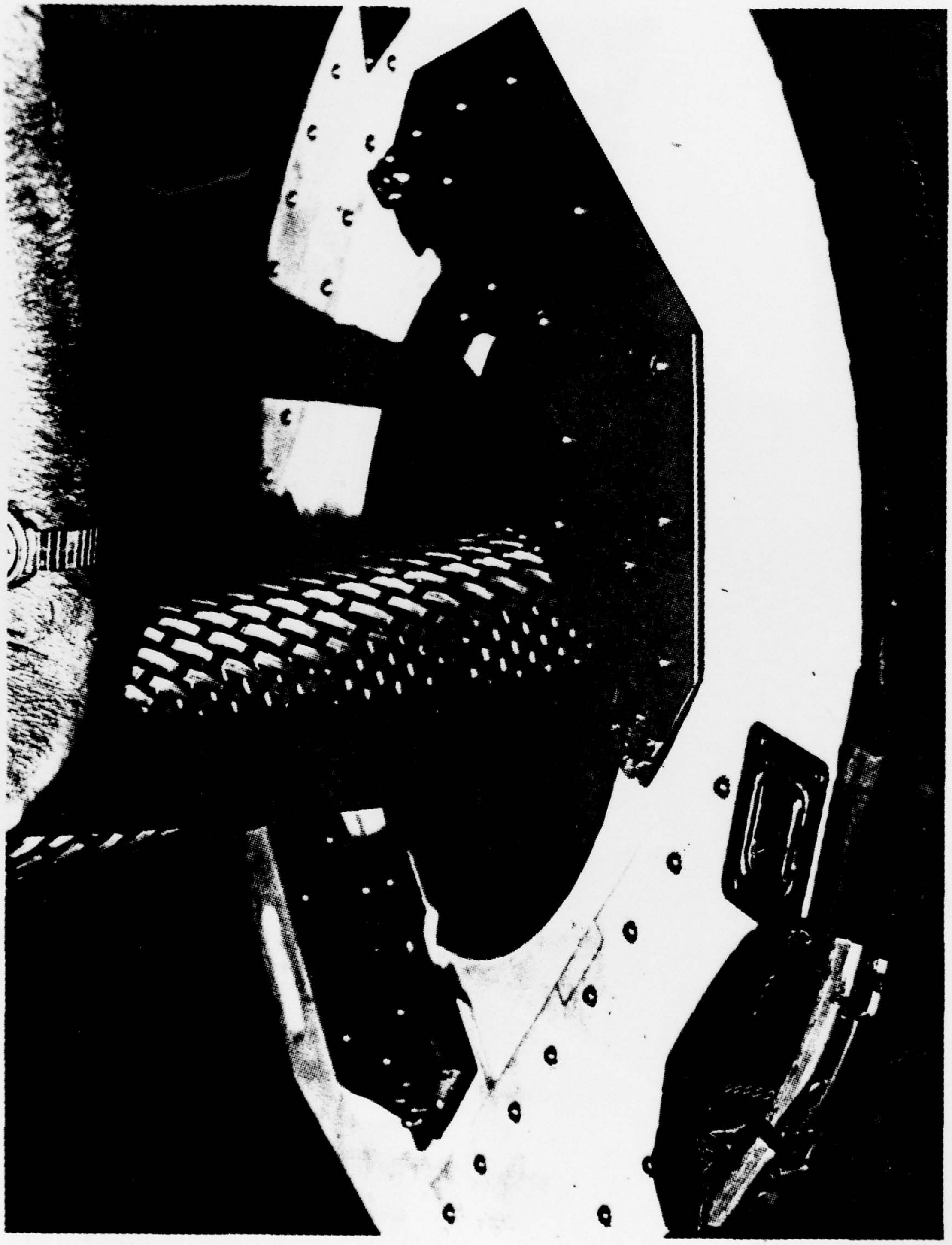


FIGURE 20. PUMP AND HOSES BEING INSERTED THROUGH OPEN SLIDES

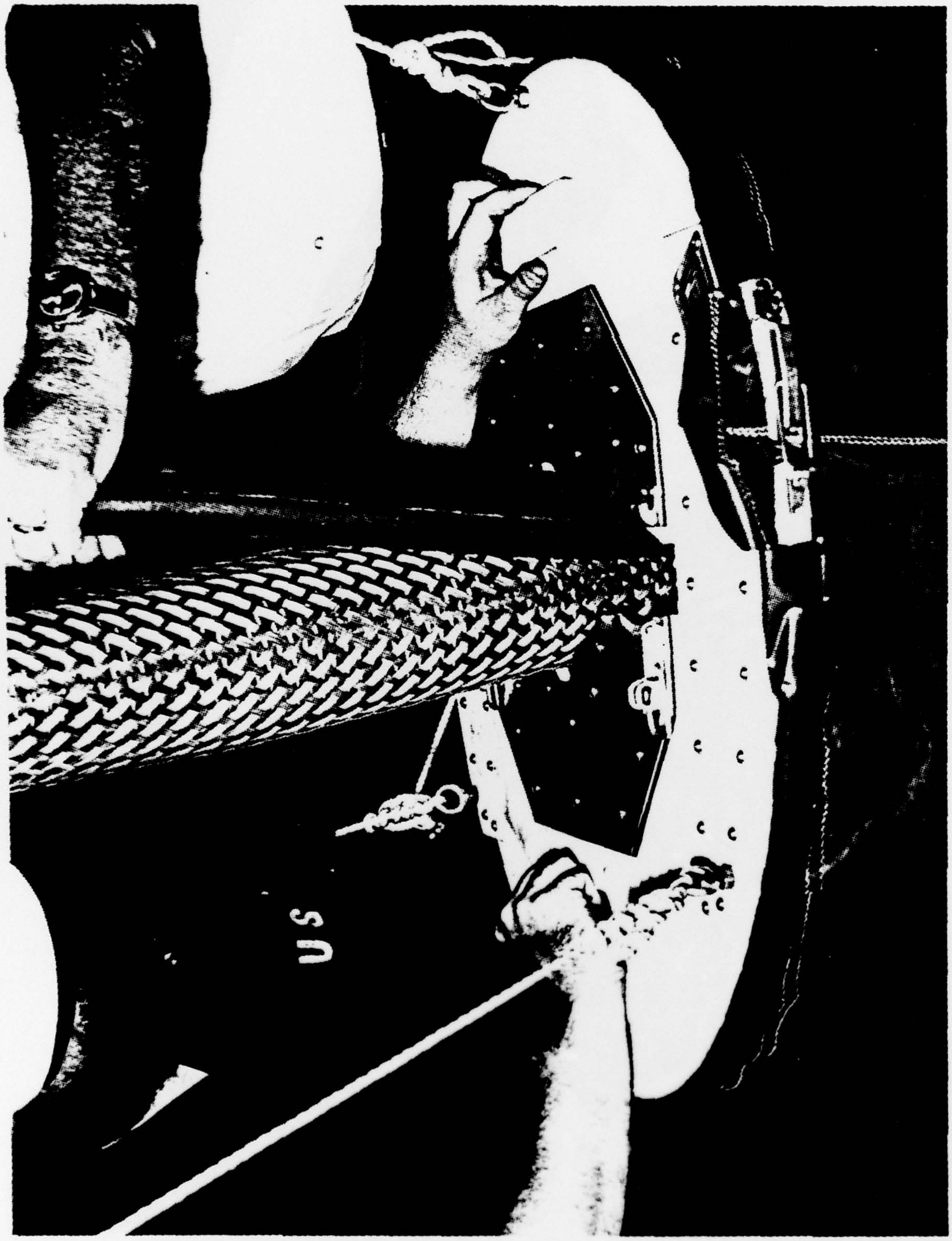


FIGURE 21. CLOSING TOP SLIDES AGAINST HOSES

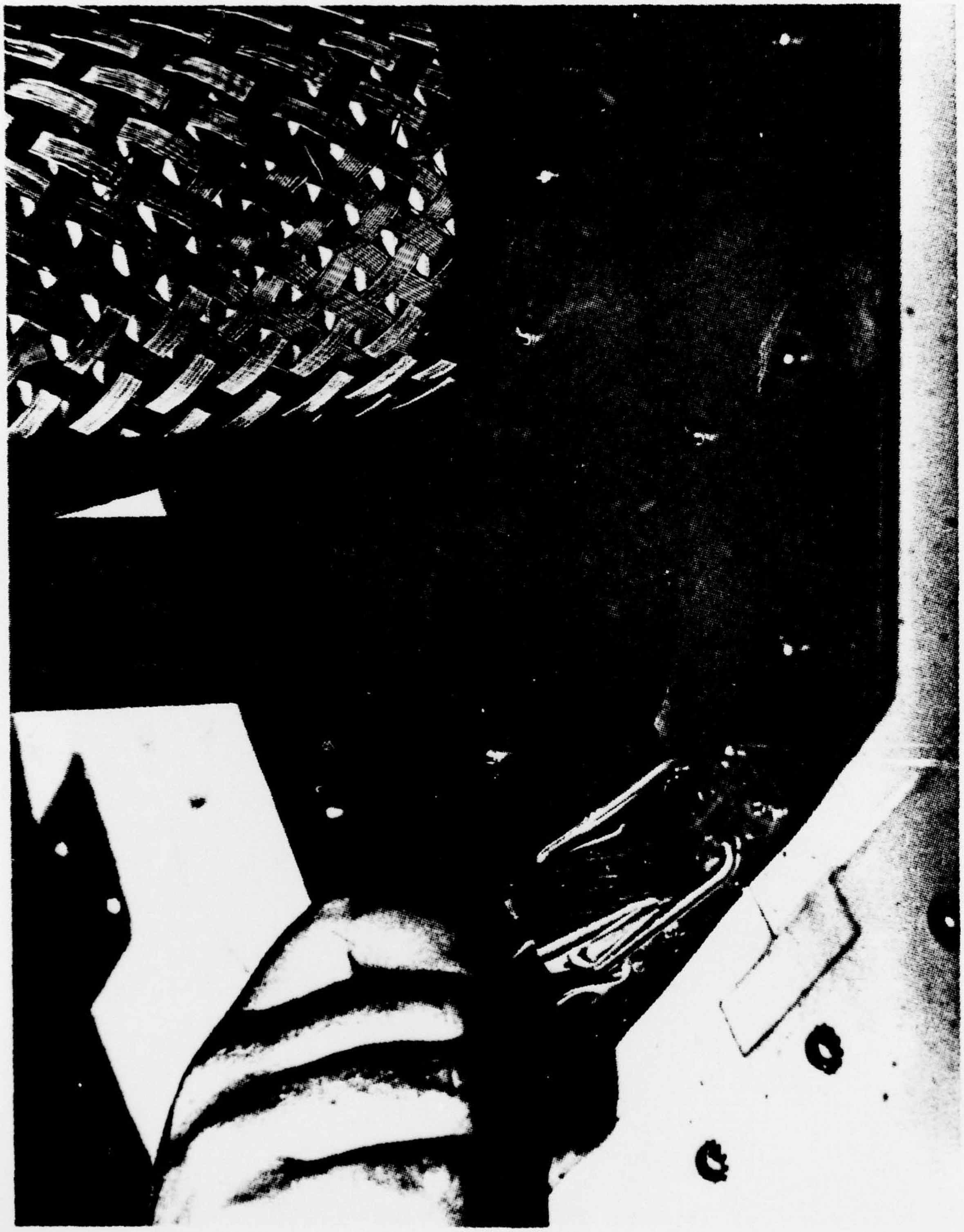


FIGURE 22. TOP SLIDES BEING LOCKED IN POSITION

FIGURE 23. VELCRO DRAWSTRAP BEING SECURED

8.0 PROTOTYPE DEMONSTRATION

The completed prototype model of the VRD was set up as shown in Figure 24 at the CG R&D Center and a demonstration was made to G-DSA, G-WEP, and G-EOE personnel on 16 August 1979.

The critique following the demonstration revealed no problems and there were no recommendations for specific changes to the prototype design.

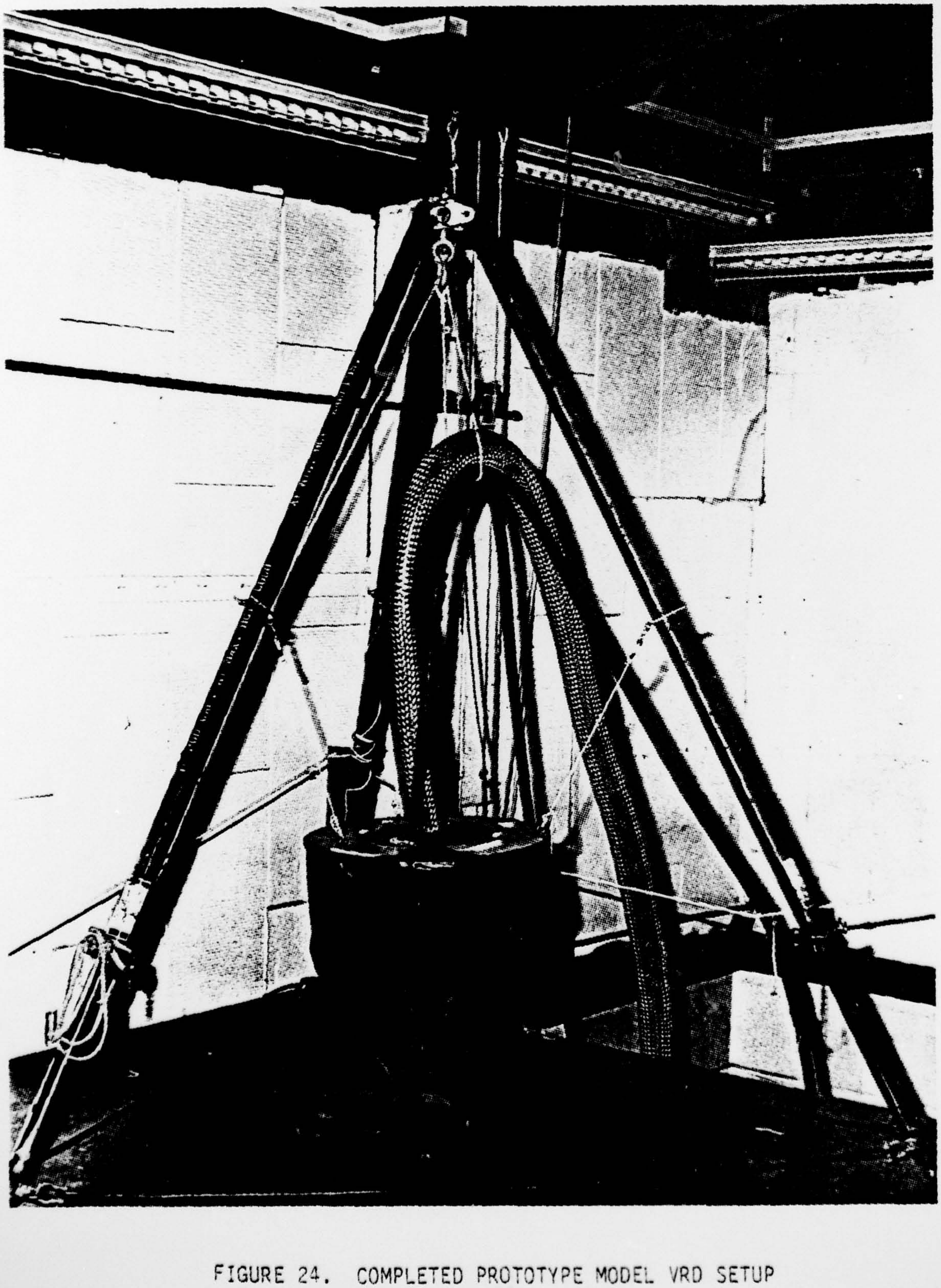


FIGURE 24. COMPLETED PROTOTYPE MODEL VRD SETUP

LIST OF REFERENCES

Ref.

1. Memo from G-EOE to G-WEP, File G-EOE - 2/61 No. 16465 dated 22 May 1978. Subject: Vapor Hazards in ADAPTS Pumping Operations.

2. Memo from G-WEP to G-DOE, File G-WEP - 4/73 No. 16465/4.3 dated 9 June 1978. Subject: Modification of ADAPTS.

3. Letter from G-DOE to CGR&DC, File 3916 Ser 10190 dated 7 July 1978. Subject: Vapor Hazards from Chemical Offloading Operations.

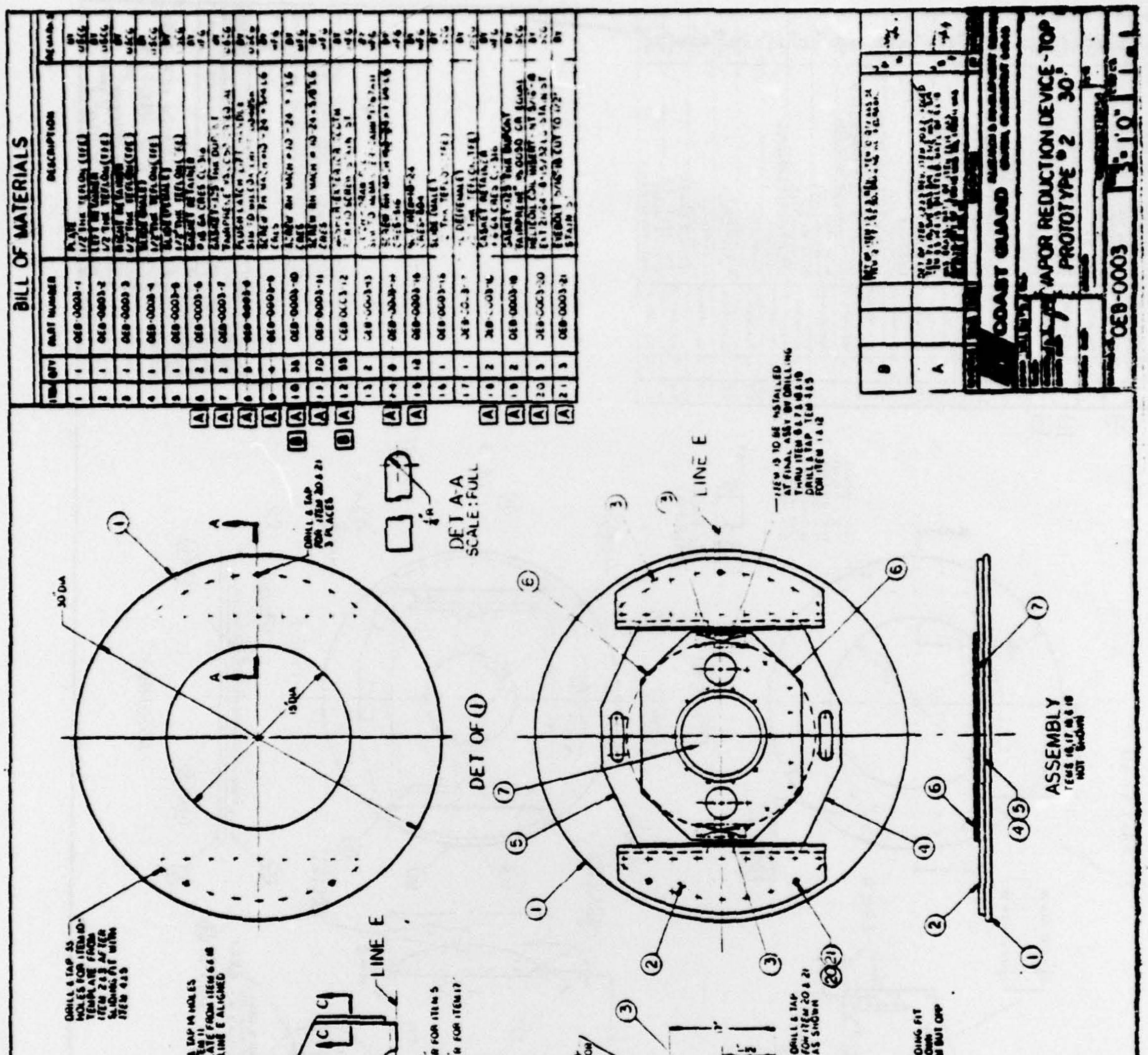
4. The General Resistance of Various Elastomers. 1970 Yearbook of the Los Angeles Rubber Group Inc.

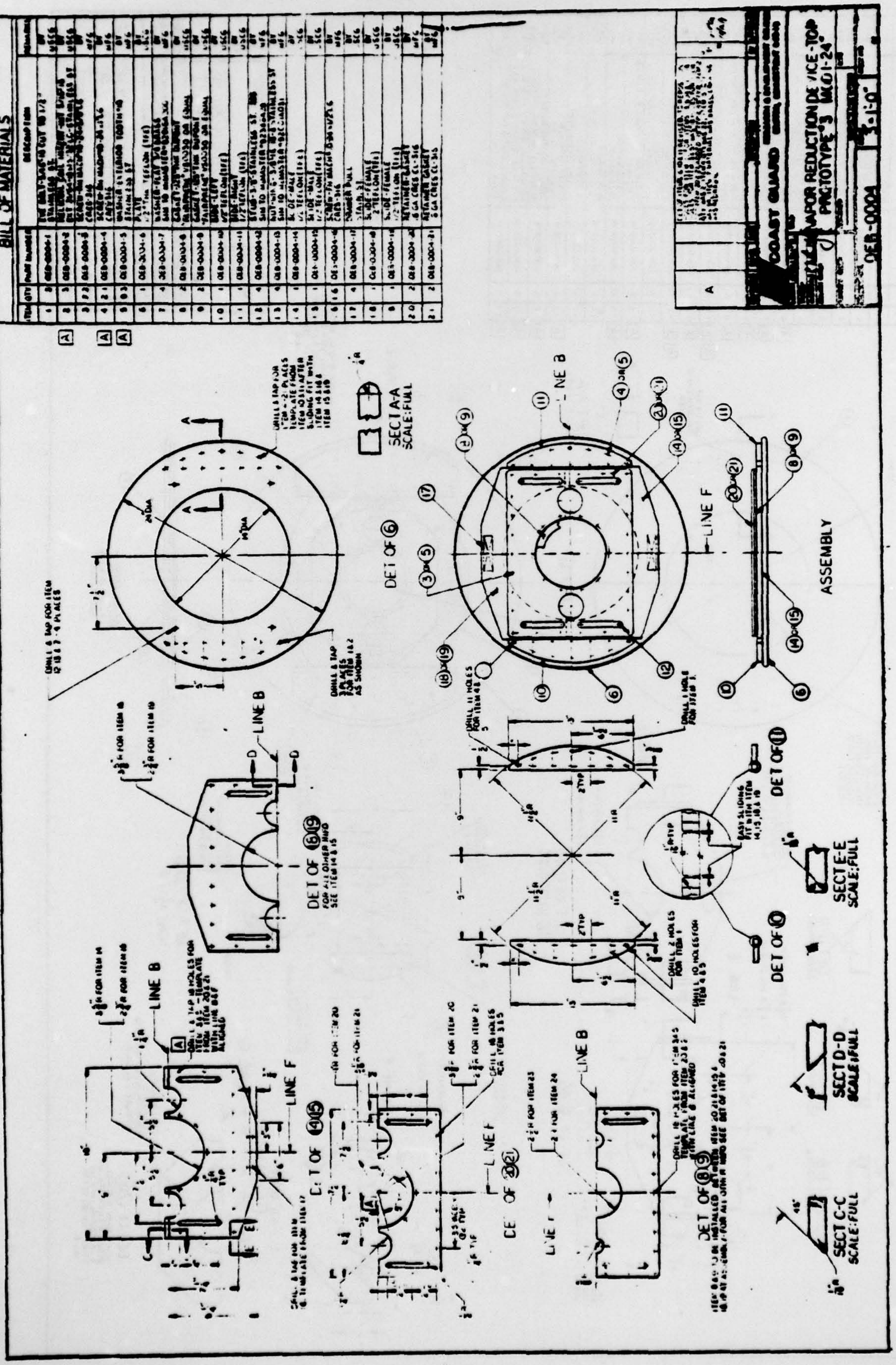
5. Development of Performance Criteria for Protective Clothing used Against Carcinogenic Liquids. Arthur D. Little Inc. 1978 for (N.I.O.S.H.) National Institute of Occupational Safety and Health.

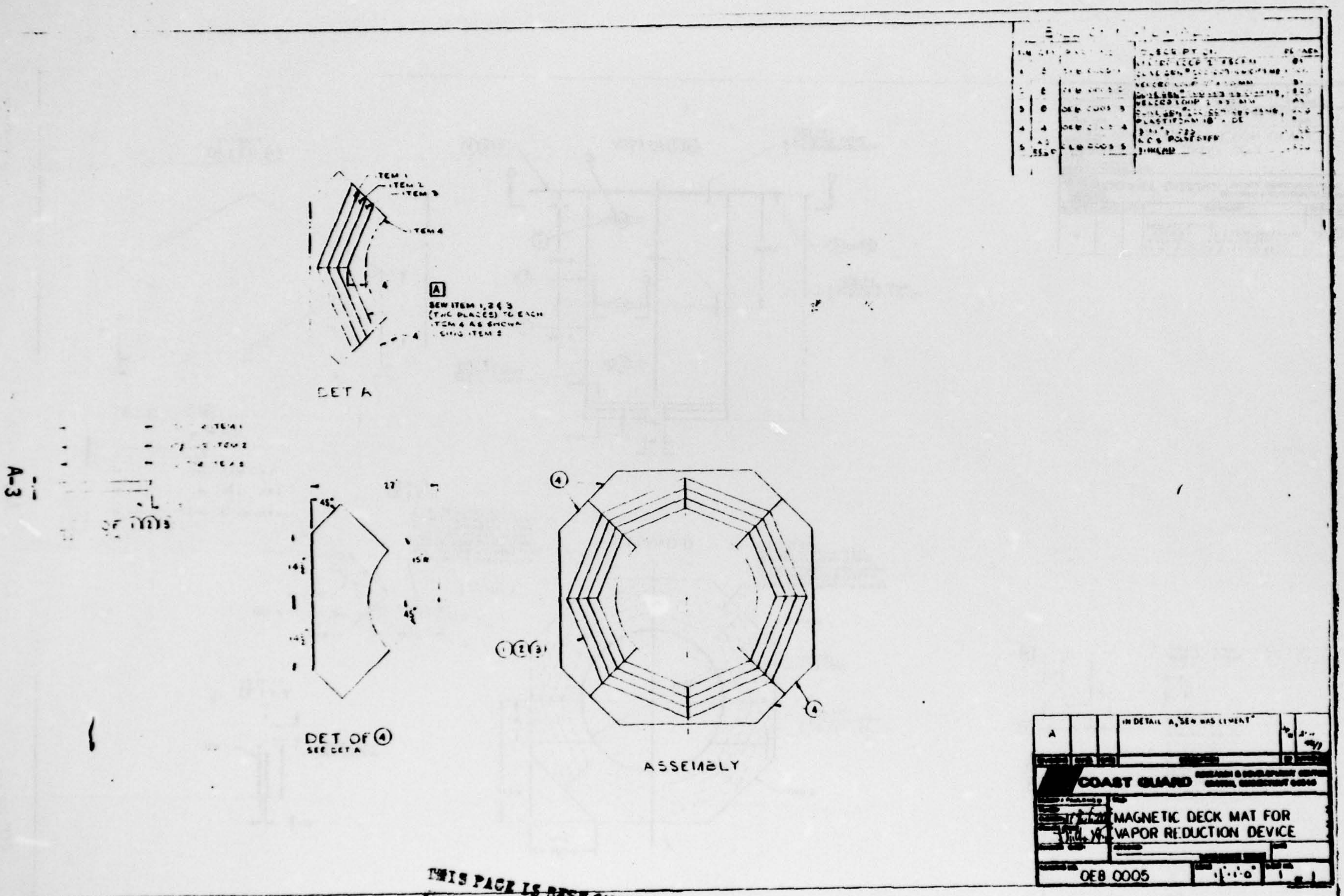
6. ADAPTS Hazardous Chemical Study, Phase II Final Report prepared for the USCG by Seaward International, Inc. 1977.

7. Corrosion Resistant Materials Handbook. Noyes Data Corporation. Third Edition. Library of Congress Catalog Number 71-128680 ISBN 0-8155-0628-7

APPENDIX A


BILL OF MATERIALS
COAST GUARD
VAPOR REDUCTION DEVICE - TOP
PROTOTYPE #2 30"
OEB-0003
DET OF 1
ASSEMBLY
DET A-A
SCALE: FULL
DET B-B
SCALE: FULL
DET C-C
SCALE: FULL
DET D-D
SCALE: FULL
DET OF 5 17
DET OF 2 3
LINE E


BILL OF MATERIALS
DET OF ⑥
SECT A-A SCALE:FULL
DET OF ⑯⑲
LINE B
LINE F
ASSEMBLY
DET OF ⑪
DET OF ①
SECT E-E SCALE:FULL
SECT D-D SCALE:FULL
SECT C-C SCALE:FULL
DET OF ⑧⑨
COAST GUARD
VAPOR REDUCTION DEVICE-TOP PROTOTYPE 3 MOD 1-24"
DEB-0004


ITEM 1
ITEM 2
ITEM 3
ITEM 4
A
SEW ITEM 1, 2 & 3
DET A
DET OF 4
SEE DET A
ASSEMBLY
IN DETAIL A, "SEW WAS CEMENT"
COAST GUARD
MAGNETIC DECK MAT FOR
VAPOR REDUCTION DEVICE
OEB 0005

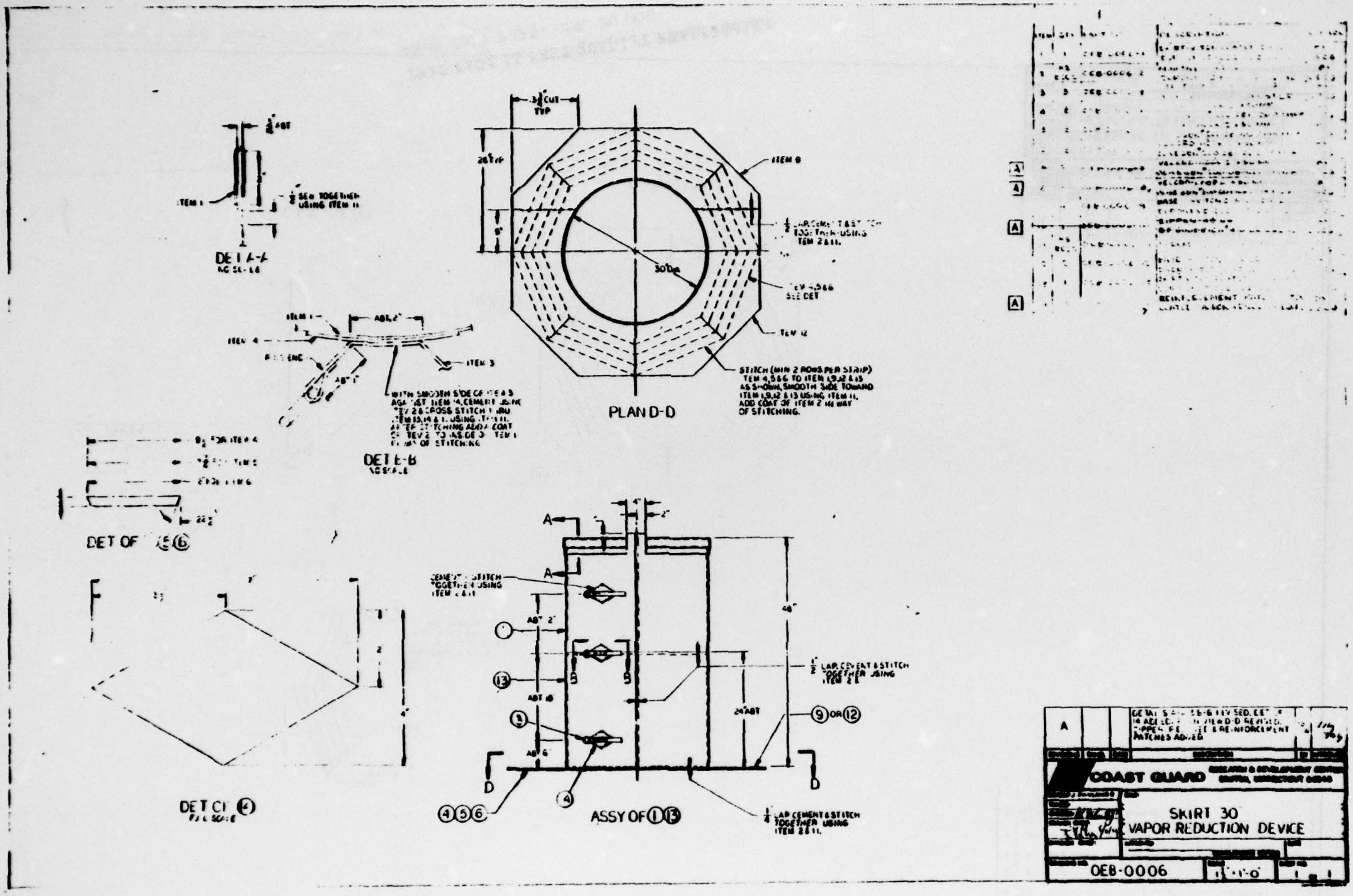

DET A-A
ITEM 1
PLAN D-D
30 Dia
ITEM 8
STITCH (MIN 2 ROWS PER STRIP) ITEM 4,5 & 6 TO ITEM 1,9,12 & 13 AS SHOWN, SMOOTH SIDE TOWARD ITEM 1,9,12 & 13 USING ITEM 11, ADD COAT OF ITEM 2 IN WAY OF STITCHING.
DET E-B
ITEM 4
ITEM 3
DET OF 4 5 6
DET C 4
ASSY OF 1 13
A
B
D
4 5 6
9 OR 12
1
13
3
4
A
COAST GUARD
SKIRT 30
VAPOR REDUCTION DEVICE
OEB-0006

FIGURE 18. VRD SKIRT AND HOOP BEING RAISED
37

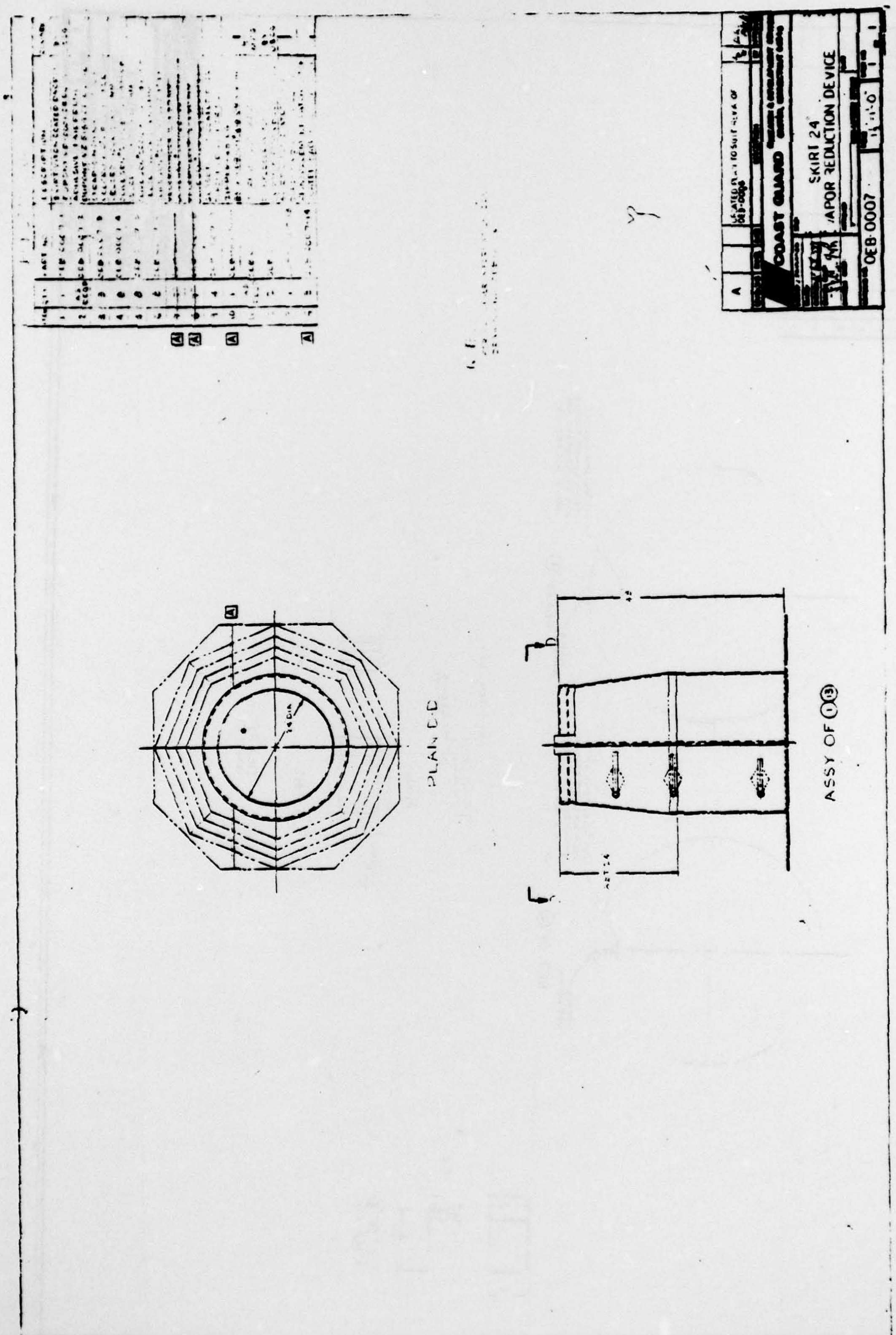


FIGURE 19. SKIRT AND HOOP LOCKED TO TOP SECTION

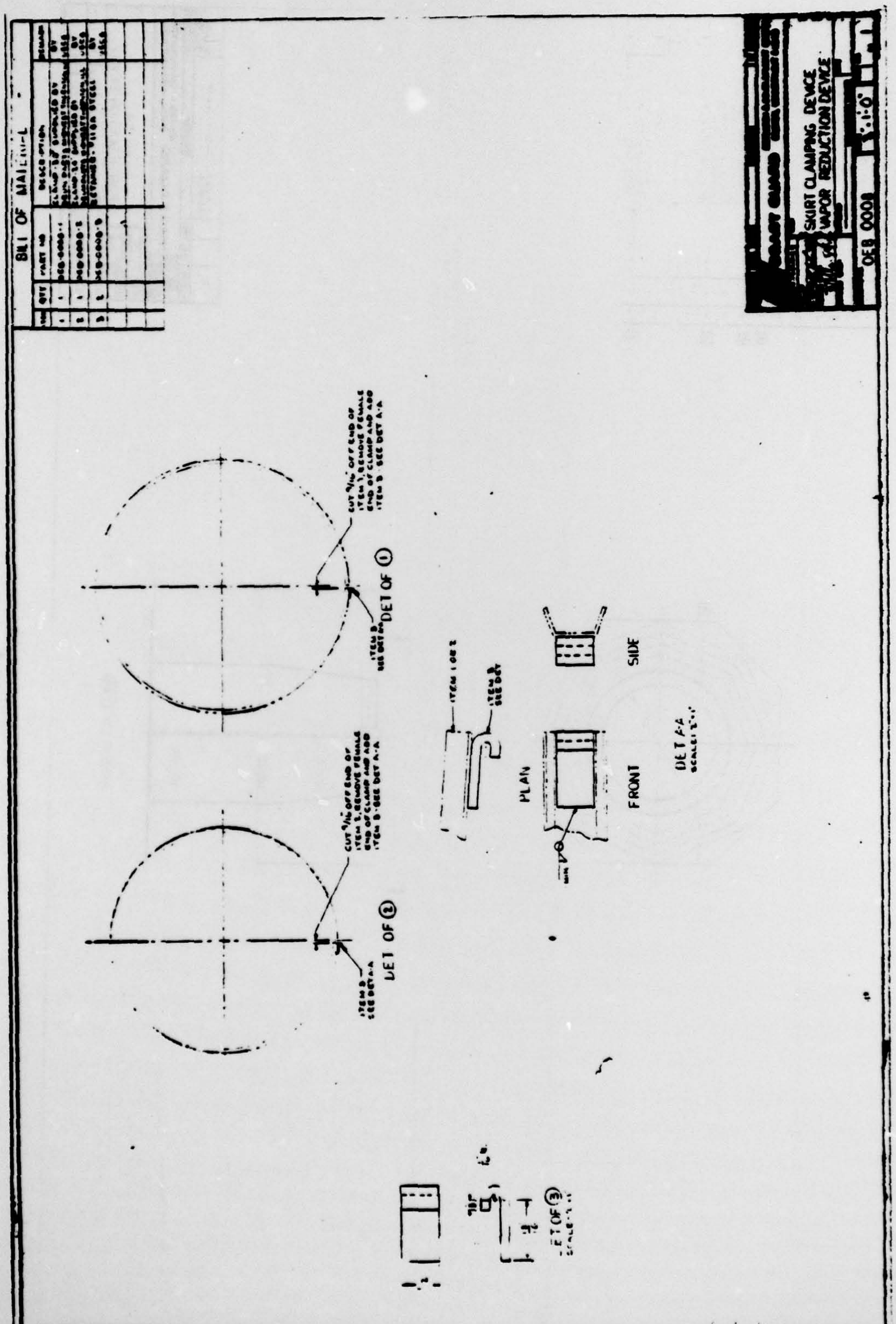


FIGURE 20. PUMP AND HOSES BEING INSERTED THROUGH OPEN SLIDES